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ABSTRACT

Eight addresses given at the Seventh Annual Science Education Conference at Claremont Teachers College in Perth, Western Australia are presented. The general conference theme was "Science Education in the Eighties." In the first paper, four areas of special opportunity for science education in Western Australia (W.A.) are identified: goals and curricula, the environment, examinations, and graduate programs. The second speech discusses systematic research designed to increase knowledge of classroom processes that optimize learning of specific science outcomes. The third traces efforts to disseminate the primary science syllabus in W.A. An evaluation report of the Physical Science Project is given in the fourth paper and the fifth paper describes an education center program and the role that these centers can play in teacher in-service in W.A. The next paper reports the findings of a study that investigated the effect of how well a student gets along with the science teacher on achievement, attitudes towards science, and academic self-concept. The seventh address promotes the use of the library as a resource for teaching science. The final paper describes a model for self-evaluation of teaching effectiveness in science. (DC)

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**7th. Annual
Science Education Conference
7th. July, 1981
Claremont Teachers College,
Perth, Western Australia.**

PROCEEDING OF THE
SEVENTH ANNUAL SCIENCE EDUCATION CONFERENCE

Claremont Teachers College

Perth, July 1981

THEME : SCIENCE EDUCATION IN THE EIGHTIES

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Most people living in Western Australia today have spent their lives in a place and in a time of plenty. The 1960's were generally optimistic years in Australia and in the Western world and science was subduing our enemies, one by one. In the 1960's we witnessed dramatic progress in medicine, in communication, in transportation, in agriculture, and even in outer space where astronauts walked. Ivan O'Riley (1968) in Giant in the Sun wrote "It will not be long before Western Australia is producing wheat like Kansas, fruit like California, and cotton like Carolina. The barren earth has been touched by the scientist's magic wand and made to bloom."

In the intervening years, however, the scientist's "magic wand" has become tarnished. The sandy earth in W.A. has not become the Garden of Eden. The southwest drainage system is salty. There is insufficient water behind the Serpentine Dam, and Perth is rapidly running out of water. The cost of energy is escalating, and in most places I have visited outside of Western Australia, there is a growing recognition that fossil fuels are a finite resource and that supplies are running out. People are beginning to question the morality of multi-national corporations and of the scientists and the governments who collaborate with them in the hope of reaping short-term profits at the expense of the environment and La Trobe valleys everywhere.

Scientists and engineers have given us aeroplanes, but they haven't stopped stewardesses from striking and paralysing a nation's transportation in April and May. They have given us highly sophisticated satellites in the sky, and yet the Telecom workers can throw Australia into communications paralysis in June. They have given us highly sophisticated energy systems, yet in Perth we have to teach by candle light on 3rd June. The very next week saw Sydney without electrical power for the better part of two days. From outside Australia our communications net in the 1970's brought us equally confusing news about a bomb in Southeast Asia, an ecological bomb, a population bomb, an energy bomb, a public morality bomb, a hunger bomb, and now an economic and employment bomb. From Vietnam to Afghanistan, from Iran to Uganda, from South Africa to Northern Ireland, from West to East from South to North, today crisis seems everywhere, and in many ways we are confused and depressed. Our technology has provided us with powerful tools for dealing with crisis, yet these tools carry within them the seeds of their own destruction. The modern era is filled with conflict and contrast. Charles Dickens (1859) might well have been speaking of today when he said:

"It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the season of light, it was the season of darkness, ... it was the spring of hope, it was the winter of despair."

There has been crisis and there has been reason to despair and to hope in all past ages. This duality is depicted in the ancient Chinese symbol for crisis which contains a character of danger and a character of opportunity. Is there opportunity and is there reason to hope today?

Through progress in technology we consume raw materials and energy at an ever escalating rate and we pollute the environment of our spaceship earth. Yet, the same technology gives us pictures of this wet, blue ball taken from miles up in space and provides a planetary prospective; it provides us with a communications system which for the first time in history allows us to know all the earth's people as our neighbours. While people have built and stockpiled weapons of mass destruction, we have at the same time developed the knowledge to eliminate the hunger and poverty which exist in the world. Should we improve levels of nutrition for undernourished children, we will simultaneously improve levels of intellectual competence and function.

At home in W.A. there are in our classrooms some students who show the signs of affluence and narcissism, yet in these same classrooms are others who are idealistic and eager to tackle the world's problems. In our schools are some teachers who are listless, but there are also inspired teachers who radiate hope and vitality.

Norman Cousins is one of several persons who has suggested that today's real energy crisis does not lie in the shortage of fuel oil, but rather in the shortage of ideas and vision of contemporary people. Amid all the confusion of the moment, there are as many reasons for optimism and hope now as ever. What can we do to lift ourselves out of our contemporary morass and frustration? What have the inspired teachers of other ages done? Think back to the great teachers in human history. What has been their disposition? Have they focused upon the darkness of the past or upon the promise of the future? Think back to the inspired teachers and leaders we have known in our own lifetimes. Have they inspired hope or engendered despair? While some of the inspired teachers I have known have been realistic, even cautious, I would contend that all of them were people who showed clear concern for students and who breathed a sense of hope to students and associates. We know that students tend to model some of their own teachers; what kind of model do we provide? One of a teacher's most important tasks is to radiate hope to students. This is particularly important at a time when we are attempting to deal with environmental and survival issues in the classroom. It is all too easy to communicate the gloom in the issues confronting us and to encourage a nihilistic philosophy in response.

HOPE INTO PRACTICE IN W.A.

The problems of the modern world are very complex and their resolution will not be easy, yet sensitive teachers can play a role in helping society gain a new sense of vision and direction. The idealism present within many young people in our schools can be a source of renewal and change that will help the democratic society become more responsive to the challenges facing us. To be effective, these students need information, they need skills and they need people who provide models worthy of emulation.

While there are many problems that confront us, I shall outline four areas of concern that provide special opportunities for science educators in Western Australia today.

GOALS AND CURRICULA

Science teachers, in particular, can help students of all ages develop skills that are relevant and meaningful in a technological society while still emphasising hope and human values. These skills include (a) careful observation and interpretation of events and conditions, (b) rational decision making based upon careful analysis of evidence and upon perceptive value judgements, (c) optimising the effects of positive events while minimising the effects of negative

events. These logical skills and a perception of causality ought to be a bi-product of school science experience, and their nurture has been advocated from many quarters especially in the recent past. For example, among the Aims for Australian schools in Core Curriculum for Australian Schools, (Curriculum Development Centre, 1980) are the mastery of:

- Scientific processes and their applications
- Logical inquiry and analysis
- Creative, imaginative and intuitive ways of thinking and experiencing
- The capacity to apply and use knowledge symbols, processes and skills
- The personal articulation of experience and thinking into value and belief systems

My impression is that these goals have not been central in the development of science curricula or in science teaching in W.A.; other important goals such as the development of science concepts appear to be the primary foci around which science teaching proceeds. If we consider the achievement of these broad goals to be important, however, then we must see that they are embodied in course activity. Problem solving, values and rational decision making are integral parts of the scientific world, and they ought to be integral parts of science curricula.

As science educators we have important responsibilities to help teachers and curriculum developers see that teaching and curricula are consistent with espoused values. Yet, recent comprehensive studies in the United States (Yager, et al., 1981), have revealed some large discrepancies between goals and practice, and some parallel situations can be observed in Australia. Our goals imply that effective introductory science programmes utilise the human being and advances in human thinking as a major organiser, especially in biology. Yet, humankind is currently only incidental in the curriculum. There almost seems to be a conscious effort to make science antiseptic and void of humans. Contemporary goals imply that current problems and issues should also be highly visible in the curriculum, yet currently, only marginal attention is given to such issues. The goals imply that good science programmes involve students in practicing decision-making skills that are involved in using scientific knowledge in a social context. Such activities take science education beyond a domain of developing science concepts, involving students in value, ethical, and moral considerations at the interface of science and society. (Student involvement in problems relating to the use of genetic engineering or nuclear energy are examples of two such activities). Currently, science is too often taught as value-free wherein the logic and structure of the discipline predominate to the exclusion of almost everything else. While concept development and an understanding of the structure of a discipline are important parts of science education, uncovering "correct" answers to narrow problems is more restrictive than it ought to be if we are to meet responsibilities outlined in the major goals for schooling. The curriculum should be culturally as well as scientifically valid. Furthermore, what is the primary message that we communicate to students about the nature of scientific problem solving through our teaching? Do we imply that the best way to succeed in science is to listen to authority and to follow our infinitely wise directions? Or do we encourage students to inquire, to use their senses and other resources, and to think for themselves? Once again, our actions in teaching should be consistent with the values we espouse.

Science programmes that are properly designed for the diverse groups of students now in secondary schools should place emphasis upon career awareness as well. Information about career opportunities can provide relevance and motivation for students and that kind of information should be an integral part of early learning. In current programmes reference to careers, when it does occur, is usually limited to highlights about a few historic personalities.

THE ENVIRONMENT

The use of the natural environment, community resources, and current concerns should be foci for study. Currently the cookbook study of contrived, classroom-bound resources is almost exclusive. In Australia systems for the protection of resources and the environment seem to be less developed than they are in some other places in the world and less developed than they ought to be. There is urgent need for attention to environmental matters by the society generally and by science teachers in particular. In addition to promoting national development, the government and people should be protecting what they have. Yet the public and the government in Australia seem relatively unaware of the seriousness of environmental problems on the long term and of the importance of stewardship of finite resources and a fragile environment. I have met high school students in Australia who honestly believe there are enough resources to go around to all who need them indefinitely. I have also met science teachers at the secondary level here who honestly felt they did not have time for these "peripheral" science issues. To them the teaching of scientific concepts and information was an overpowering goal. Science teachers have a responsibility to become better informed and to help their students become better informed about environmental issues. The problem is a complex one, but, when science teachers reach out to the idealistic students in their classrooms, there is reason to hope they will make a difference in their communities. Subsequently their elected parliamentary representatives will also become better informed resulting ultimately in more enlightened decisions on important environmental matters. Science teachers could become prime movers of community awareness on environmental issues, but they need leadership. They need prophets within the profession of science education who will depart from the status quo and who will help them see what needs to be done.

EXAMINATIONS

To be consistent with the global educational goals to which we have been referring, testing and evaluation should assess the development of rational, decision-making strategies in a science and society context as well as the development of conceptual understanding in science. Currently, of course, testing and evaluation very often emphasise replication of assigned information and in too many classrooms students are merely expected to write "correct" solutions to preplanned problems. In my opinion, examinations present special opportunities and special problems in Western Australia. Exams are an important part of the reality of education in W.A. today, and teachers do have a responsibility to help their students perform as effectively as possible on those examinations. However, professional teachers cannot use exams as an excuse to justify poor teaching, and that seems to happen all too often!

Some people perceive serious inequities in the TAE examination system, but the problems have not been clearly explicated. Whether or not the system is a good one, there are some serious communications problems, at least, that need to be resolved. While some teachers claim that the exams emphasise misplaced priorities, they seem not to know how to influence or change those priorities, and they are inclined to place the blame for the dilemma on mysterious individuals who inhabit the State Department of Education. Persons in the State Department, on the other hand, explain that it is really the tertiary institutions that set the priorities for what is to be examined. People in the tertiary institutions often do not even seem to have heard that there may be a problem. Examinations can be an important way to supply some stability to education in a dynamic world. They can also promote meaningful curriculum change. Yet, if there is inadequate dialogue during their preparation, they can be inhibiting; they can become an inertial drag on meaningful change. Exams can be an

important external mechanism for providing feedback to communities, schools, teachers, and students on their effectiveness in reaching certain educational goals. Yet, if the exams are insensitive to important goals of contemporary schooling, the feedback may even be damaging to the growth of a society and its young people. For example, the exams may very well be a major factor in the reason why teachers do not perceive that environmental issues ought to have an important place in science teaching. With diminishing numbers of young "school leavers", secondary schools today are inhabited by students having a broader range of academic and non-academic orientations than was the case in past decades. Ministering to the broader needs of these students requires new and relevant programmes. Yet, as you know, in W.A. topics and subjects that are not examined do not have the status of those that are. Status accrues similarly to teachers of TAE subjects. Thus, exams are one factor in the sluggishness of schools to respond to the broader needs of secondary students today.

Teachers and educators, as members of a professional community, have a responsibility to clarify discrepancies between goals and practice in the schools and there are some obvious discrepancies. They must speak out both individually and collectively, not only to clarify the problems of the moment, but also to describe their dreams of what ought to be. Professional organisations as well as state departments could commission position papers outlining selected problems, such as those related to examinations, and alternatives for the resolution of those problems. They could call for a congress to examine such problems and their resolution. If professional organisations do not currently function in this way, then sensitive and assertive professionals will invest the effort and time to build organisational structures enabling the profession to participate responsibly in the democratic society. Worthwhile change is seldom easy, but there is evidence that it is possible in the democratic society of Australia when individuals and organisations are sufficiently concerned to work for that change.

GRADUATE PROGRAMMES

One of the opportunities in Western Australia today lies in the relatively large number of teachers who have become interested in seeking advanced education and in pursuing graduate programmes. Due to the large numbers involved, it will be a real challenge to provide them with experiences of high quality that can be meaningful to their own growth and development. Yet, most of the graduate students are generally inservice teachers. Thus, many opportunities will present themselves to integrate theory with practice and to build experiences with children into the too often abstract world of teacher education. They work in laboratories in the schools where they can assess student development, observe student behaviour, and where they can try out and evaluate specific teaching skills, strategies, and curricula. The presence of so many teachers also open doors not available before to clinical experiences in the schools for first degree, pre-service students.

The presence of classroom teachers in large numbers provides opportunity for meaningful research on classroom learning that can involve those teachers in investigations with their own students. The right kinds of research experiences can be an important aspect of the teacher's own development and can provide data for broader research studies not readily obtainable in many other parts of the world where access to teachers and classrooms is more restricted. These graduate student/teacher/researchers can become an important part of the system through which worthwhile research proceeds.

The presence of external students in graduate programmes in W.A. in fairly large numbers presents another challenge and opportunity. For some years, futurists have been talking about the importance of life-long education and about the need to

utilise the electronic media more extensively. Educators have also advocated more personalised teaching that is sensitive to the needs of diverse students, and they have advocated continuing education in the local community. (That is transport education, ideas, and information rather than people.) Studies at the Open University in England, however, where large numbers of students learn by mail and television have revealed repeatedly that though students can successfully pass diagnostic unit tests, fifty percent of them fail the final exams (McIntosch 1977). For one reason or another, the mode of learning has not facilitated, for many students, the ability to synthesise the bits of information that were learned. Can systems be developed that will be efficient, yet overcome these very serious problems? External students in large numbers increase the complexity of your task, but they provide an opportunity to research these questions, they provide an opportunity to explore the use of new strategies and new media in teaching.

HOPE AND THE FUTURE IN W.A.

I have outlined four areas of special opportunity for science education in W.A., and certainly there are many more you can identify. Wherever one travels in the world, human problems abound, and Western Australia is no exception. Yet, there may be greater resources here in Australia that can help in resolving some of these problems than there are in other places. We can treat these problems as horrendous and participate in a self-fulfilling prophecy of gloom. Or we can treat them as opportunities for growth and development.

Each person has his or her own view of the world that is a function of genes and experiences with religion, science, people, and culture. A person who has hope has an expectation that some good can come from the chaos in the surrounding world. He or she may be cautious, but doesn't let that caution impede all action. An educated person doubts and questions; he or she also develops positive hypotheses and affirms.

We need not over react to contemporary prophets of salvation or of despair. Throughout human history, crises have encouraged the search for new solutions; they have been a source of renewal. Those of us who are teachers must speak out on what can be done in education to enrich students' potential to make contributions to society in the future. While we ought not to communicate a naive optimism that is unrelated to the complexity of modern life, despair is a self-fulfilling prophecy.

In many ways Australia bridges a gulf between older societies where there is evidence of institutional "hardening of the arteries". Though the group of science educators in Australia is small, Australians have the potential for creative leadership. Among other things, science educators here tend to be better informed about both the European/British and the American literature than do persons in either of those places. There are also some unusually well-stocked libraries and curriculum resources right here in Perth. But that is only the beginning; though it is wise to build on the best that is available elsewhere, Australians need not remain confined to paradigms, instructional systems, and institutions designed for another world and reality.

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TOWARD AN UNDERSTANDING OF TEACHING AND LEARNING

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Research in classrooms can provide a basis for rational decision making on teaching and learning at all educational levels. Through the use of analyses of classroom processes and outcomes valuable insights can be obtained into the effectiveness of teaching strategies used to promote pupil learning. An understanding of classroom processes necessitates the use of a broad range of research techniques. The nature of a problem to be solved together with the current state of knowledge in the area concerned will often determine whether case study research, naturalistic studies, or experimental investigations are the most appropriate form of inquiry. In some instances the findings of case study research can be further investigated in naturalistic settings after which experimental research is desirable. To complete the cycle, the outcomes of experimental research will often lead to additional case study or naturalistic investigations.

An example of effective use of diverse methodologies is found in research on wait-time, conducted over a fourteen year period of time (e.g. Garigliano, 1972; Lake, 1973; Rowe, 1974 a,b; Tobin, 1980; Tobin and Capie, 1980 a). The initial problem related to low levels of pupil inquiry behaviour observed in classrooms implementing trial versions of the Science Curriculum Improvement Study (1971). Data gathered from naturalistic research suggested that instruction in science classrooms was characterised by a short time interval separating speakers. In an attempt to determine whether this pattern of verbal interaction was peculiar to the particular classes in the sample or a characteristic of science teaching in general, Rowe (1974, a, b) examined additional "naturalistic" data. From a sample of two hundred tape recordings, only three were discovered which demonstrated desirable patterns of pupil inquiry. Close examination of the three anomolous tapes revealed that pauses separating speakers in these classes were often as long as three to five seconds in duration. The discovery of a possible relationship between length and location of pauses, and desirable features of pupil inquiry led Rowe and others into an intensive study of wait-time. Many of these studies imposed rigorous controls so that the effects of extended wait-time on specified teacher and pupil outcome variables could be examined in detail. Numerous micro-studies involving large numbers of teachers each working with small groups of children were followed by comprehensive classroom based

research designed to substantiate the results of micro-studies.

Thus, investigations of wait-time have utilized many forms of inquiry to seek solutions to problems that have emerged as research has progressed and understandings have grown. In a similar manner research into other classroom process variables, such as praise (Brophy, 1980) and pupil risk taking behaviour (Doyle, 1980) have incorporated diverse empirical and non-empirical research methodologies. The purpose of this paper is not to argue for one form of inquiry over another, but to discuss contexts where empirical research is an appropriate form of investigation.

Two important philosophical questions that persist in education relate to: identification of the ends of education; and whether the educational means justify the ends. Solutions to the problems embodied by these questions are not offered in this paper.

The questions which are addressed relate to the relative effectiveness of educational means for specified ends. Faced with a decade of decreased funding at all educational levels and increased competition for limited educational resources, studies of educational productivity are an emerging priority. One important aspect of educational productivity relates to the effectiveness of the classroom teacher. Research is needed at all educational levels to identify teaching variables that positively influence desirable pupil outcomes. As understandings of teacher effectiveness increase, an empirical basis for classroom processes can be developed. Despite the intuitive appeal of developing an empirical model of teacher effectiveness, however, research in classrooms is faced with numerous conceptual, methodological, and ethical challenges. Each of these challenges is important and must certainly be addressed if research is to provide the answers that are required to improve classroom practice. This paper will not deal with methodological or ethical issues, but will address conceptual aspects of process-product research in classrooms and teacher training programs. Although examples are chosen from research in primary and secondary science teaching, the principles developed should be generally applicable to teaching at all levels.

Frameworks for Classroom Research

A simple model that is often applied to classroom settings describes changes in pupil outcomes in terms of measures of teacher effectiveness. Although much of the research using this model has been conducted in naturalistic settings, research questions are usually presented in a causal framework supported by theoretical arguments that variation in measures of teacher performance cause

a significant amount of the variation observed in pupil outcome measures. The model, which is presented in Figure 1, is most useful in a macroscopic sense when class means for specified pupil outcomes are related to teacher performance measures.

Insert Figure 1 about here

The research literature contains numerous examples where positive correlations between teacher performance measures and pupil outcomes are regarded as essential validity criteria for the teacher performance measures. For example, researchers associated with the Georgia Teacher Assessment Project have investigated the strength of relationships between teacher performance measures and pupil achievement, time on-task, and perceptions of the classroom learning environment. Empirical investigations conducted in a wide range of grade levels and subject areas were used as a basis for retaining, modifying, and rejecting measures of teacher performance associated with the Teacher Performance Assessment Instruments (Capie, Johnson, Anderson, Ellett and Okey, 1979). In other research examples, teaching variables such as cognitive level of questioning (e.g. Gall, Ward, Berliner, Cahen, Winne, Elashoff, and Stanton, 1978), wait-time (e.g. Rowe, 1974 a), and mastery learning (e.g. Dillashaw and Okey, 1981) have been investigated in conjunction with a range of pupil outcomes.

Despite the simplicity of the model, a framework is provided for investigating the effectiveness of what teachers do in classrooms. Perhaps the most important application of the model is in validation of teaching studies such as those conducted at the University of Georgia. The limitations of the model relate to its simplicity. No attempt has been made to incorporate variables associated with learner processes that must occur in the classroom if learning is to occur.

An alternative model (Figure 2) links teacher performance variables through pupil engagement to pupil achievement. Initially proposed by Medley, Soar, and Soar (1975), the model highlights the importance of pupil engagement in the learning process. The quality and amount of pupil engagement are each likely to have a direct influence on the amount of pupil learning that occurs. Equally apparent from the model is that teacher behaviours cannot have a direct effect on pupil learning. Pupil engagement mediates the effects of teaching on learning. Thus, pupil engagement represents a crucial indicator of teacher effectiveness and is an important validity criterion for teacher performance measures.

Insert Figure 2 about here

As it stands, the model presented in Figure 2 is too simple for many of the research questions that need to be answered about learning in classrooms. When individuals are the focus of research, learner attributes need to be incorporated in the model. Prior research and theoretical considerations suggest that certain learner attributes will directly influence the quality and amount of engagement and will often determine how a learner reacts to particular styles of teaching. An expanded model (Figure 3) indicates probable relationships between specified learner attributes and engagement. Among the attributes that are potential mediators of engagement and achievement are cognitive aptitude, locus of control, and pupil perceptions of the classroom learning environment.

Insert Figure 3 about here

Learner Attributes

Cognitive aptitude is a variable that has been shown to be related to engagement and achievement in middle school science classes. For example Tobin and Capie (1980 b) reported formal reasoning ability of pupils in Year 6,7, and 8 classes to be significantly related to the amount of pupil generalizing behaviour. Pupils with higher levels of formal reasoning ability provided a higher incidence of generalizing statements than pupils with lower levels of formal reasoning ability. Formal reasoning ability was also reported to be significantly related to science achievement and retention.

Locus of control, defined as the tendency for individuals to accept responsibility for their academic success and failure has theoretical appeal as a variable likely to influence engagement and achievement. To some extent research on locus of control has been hampered by the use of pencil and paper measures with low internal consistency reliability. As a consequence, high correlations with engagement and achievement are not to be expected, and generally were not obtained. However, the results of several studies have supported the hypothesis that pupils who accept responsibility for academic success or failure exhibit higher engagement rates and achieve at a higher level. For example, Tobin and Capie (1980 b) reported a positive correlation between locus of control and pupil attending during science instruction. Other research (e.g. Rotter and Mulry, 1965) has indicated that pupils with an internal locus of control spend more time deliberating about decisions and consequently take more time to arrive at a decision than pupils with an external locus of control. Saunders and Yeany (1979) reported that pupils with an internal locus of control attained higher science achievement scores than pupils with an external locus of control.

Perceptions of the classroom learning environment have also been related to pupil achievement gains and pupil on-task rates. Research reported by Fraser (1980), Moos (1979), and Walberg (1979) has identified dimensions of the perceived learning environment such as: opportunities to interact with the teacher; encouragement to participate; and emphasis on inquiry skills as variables likely to influence pupil engagement rates and achievement.

Many learner attributes could be included in the model as the range of pupil outcomes and engagement categories is extended beyond the cognitively oriented outcomes that have been investigated in recent research. For example, measures of creativity would probably be required if creative classroom behaviour and creative problem solving were considered in a study.

Teacher Performance Variables

Traditionally research on teaching has been concerned with investigations of relationships between teaching strategies and pupil achievement. However, research of this type has often ignored the mediating role of pupil engagement and personal attributes associated with learning. Since teachers cannot have a direct influence on learning, an initial focus for research should be on identification of teaching strategies that can be used to promote desirable types of pupil engagement. Of course a complete understanding of the manner in which teaching influences engagement necessitates concomitant investigation of the relationships of selected learning attributes on engagement.

As an illustration of the types of teaching variables that have been considered in process-product studies soliciting, explaining, and classroom management are briefly discussed in relation to pupil engagement rates.

From a theoretical perspective, teacher solicitations are likely to have an influence on pupil engagement rates. By asking questions or directing pupils to a course of action, teachers are able to provide a cognitive focus that enables pupils to practice the behaviours specified in the objectives. Thus, if solicitations are referenced to the instructional objectives, they provide a means for teachers to promote specific types of pupil engagement.

Explaining is also an important instructional variable. Through explanations, teachers are able to impart knowledge to pupils, clarify areas of misunderstanding, or elaborate on information that has been previously provided. Unfortunately, teacher explanations appear to engage pupils in a covert mode by having them attend to what is being explained. Although research has not yet addressed the question of the relative importance of overt and covert engagement, overt engagement may be easier to sustain in classrooms. If this is the case, the amount of time

allocated for explanations should be minimized so that pupils are not required to concentrate in an attending mode for extended periods of time.

A probable relationship between the quality of teacher explanations and pupil engagement rates occurs for explanations of procedures to be used by pupils in a specific activity. For example, if a teacher clearly explains how pupils should go about planning an investigation to solve a problem pupils are likely to exhibit higher rates of planning behaviours than those in classes where such explanations are not offered. That is to say, active engagement can be fostered through the use of explanations of this type.

Tobin, Capie, Ellett, and Johnson (1980) identified an aggregation of ten variables related to classroom management. Subsequently, Capie, Tobin and, Bowell (1980) reported moderately high significant correlations of classroom management measures and science achievement scores for pupils in elementary grades. Tobin and Capie (1980 b) reported a significant correlation between classroom management and pupil engagement rates for pupils in grade six, seven, and eight science classes. Unlike the teacher variables previously discussed, classroom management is a composite variable comprising ten teacher performance indicators which are separately rated on a five point scale. Factor score coefficients are used to obtain classroom management measures from the raw scores on each indicator. A brief description of each performance indicator is provided in Table 1.

Insert Table 1 about here

Models for Teacher Training

Once a variable has been validated in process-product studies, interest shifts to training studies designed to identify optimal procedures for training teachers to demonstrate specific desirable behaviours. For example, following a number of wait-time studies, several were designed to specifically assess the effectiveness of different training programs. A generalized procedure for planning training studies is presented in Figure 4.

Insert Figure 4 about here

The model analysis phase of Figure 4 represents a stage when variables in the model are defined, and the model is applied to examples of teaching on audio - or video-tape. In the model analysis phase teachers should develop a thorough understanding of the behaviours to be used during instruction. The behaviour modeling

phase is where teachers are provided with an opportunity to demonstrate each of the behaviours in the model. This phase will often be conducted with small groups of pupils from school or peer groups. A record of the behaviour modeling phase is usually obtained with audio - or video-tape.

The third phase of the process requires the behaviour modeling phase to be analyzed. In most instances self-analysis is used because of the importance of feedback so that each teacher knows the extent to which behaviour modeling was successful. Examples of teaching behaviours that can be dealt with in this way are quite diverse. For example, any of the teaching variables discussed in this paper would be appropriate. To illustrate the applicability of the model teacher wait-time, classroom management, and data processing are discussed as examples. Teacher training research applications are also discussed below.

Teacher Wait-Time

Teacher wait-time is defined as the duration of the silent pause which precedes teacher discourse. The diagram presented in Figure 5 indicates two types of pause that are pertinent to measurement of teacher wait-time.

Insert Figure 5 about here

The model analysis phase for a teacher wait-time training program consists of providing teachers with a concise definition of teacher wait-time followed by video-taped examples of classroom interaction demonstrating short and long teacher wait-times. In each case a quantitative value is provided for the mean teacher wait-time used.

In the second phase a short segment from a lesson is taught in a small group setting with school pupils or peers. During the lesson the teacher endeavours to use an average wait-time greater than three seconds. Following the teaching phase wait-time is measured and feedback is provided to teachers on the magnitude as well as personal feedback on techniques for implementing an extended wait-time. Additional teaching and feedback might be necessary if teachers are to effect a teacher wait-time of the desired magnitude.

Classroom Management

The model analysis phase for classroom management parallels that described for teacher wait-time. In this case two video-tapes can be used to provide teachers with examples of how to rate teacher performance and opportunities to practice rating each of the performance indicators. Table 2 contains an operational definition of a sample performance indicator. Each of the performance indicators

is characterized by a five point rating scale with defined scale points.

Insert Table 2 about here

The behaviours to be modeled in this example are best demonstrated with groups of ten or more school pupils. Following the behaviour modeling phase, classroom management can be self-assessed from video-tape using the model as a basis for assigning ratings and noting what needs to be done to attain higher ratings.

Data Processing

The Data Processing Observation Guide (DPOG) (Yrany and Capie, 1979) is a different model to those previously described. The DPOG contains examples of behaviours that are demonstrated when data are manipulated and interpreted. The purpose of a data processing training program is to enable teachers to acquire teaching strategies that will enable their pupils to practice the operations contained on the DPOG. Thus teachers need to be able to demonstrate DPOG operations, explain how pupils can use DPOG operations, and question or direct so that pupils are required to use DPOG operations.

In the model analysis phase each operation is carefully defined and explained to teachers. Video-tapes of science lessons are then used to provide examples of each operation in classroom settings. Teachers are also provided with an opportunity to identify each operation as demonstrated by pupils and the teacher on the video-tape.

Small groups of school pupils or peer groups are quite suitable for use in the behaviour modeling phase. In the analysis phase, the DPOG is used to determine which behaviours were exhibited, whether a pupil or the teacher processed the data, or whether interactions about data processing occurred. Lesson profiles enable each teacher to determine whether the pupils were provided with sufficient opportunities to practice the DPOG operations.

Teacher Training Research

Systematic analysis of data collected in the analysis of teaching phase allows the effectiveness of a training program to be assessed in absolute terms or to be compared with alternative training programs. The dependent variables in investigations of this type are teacher performance variables. Teachers involved in a training program should exhibit behaviours that relate to the objectives of the program, whereas teachers who were not involved should be less likely to exhibit the behaviours.

Of course the effects of a training program can also be assessed in classroom contexts through analyses of pupil engagement rates and achievement. If this procedure is adopted, teacher training strategies may be initially related to teacher performance, then to pupil engagement, and finally to pupil achievement. The use of multi-phase procedures in conjunction with statistical analyses such as path analysis, structural analyses using programs such as LISREL (Joreskog and Sorbom, 1978), and econometric analyses such as two and three-stage least squares regression, allow for multivariate modeling of teaching and learning. As knowledge increases variables can be added to the model. For example, in the same way that learner attributes were considered when pupil engagement was a concern, teacher attributes can be considered when teacher performance is considered as a dependent or an independent variable.

Conclusion

Approaches to science teaching and curriculum implementation in Western Australian schools have been largely based on philosophical positions adopted by senior personnel in the State Education Department. Personal opinion, supported by a central educational system and external examinations, has produced a comparatively uniform science curriculum throughout the State. Few changes have been based on research findings.

A preferred basis for initiating change in science classrooms is to conduct a systematic research program designed to increase knowledge of the classroom processes that optimize learning of specific science outcomes. Although methodological problems such as lack of randomization and the need to utilize intact groups can be regarded as drawbacks to serious research, replicated research findings would provide convincing support for introducing programs or changing approaches to teaching. With appropriate care in research design, investigations can be conducted in an unobtrusive and non-disruptive manner. Indeed, because of the concern for valid and reliable measurement, science programs can often benefit from concomitant involvement in research. On a personal note, classroom research enables a philosophical ideal to be approached in that teaching, learning, and educational research should not be regarded as separate endeavours since each represents an integral component of the process of education.

Classroom research cannot be regarded as complete unless complementary training studies are conducted so that beneficial research outcomes can be implemented into classrooms. In this way research can increase our understanding of teaching and learning and impact on pupil learning, the *raison d'être* of schooling.

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Table 1

Teacher Performance Indicators Defining Classroom Management

Uses teaching methods appropriate for objectives, learners and environment.

Gives directions and explanations related to lesson content.

Provides learners with opportunities for participating.

Maintains learner involvement in lessons.

Reinforces and encourages the efforts of learners to maintain involvement.

Uses instructional time effectively.

Demonstrates sensitivity to the needs and feelings of learners.

Provides feedback to learners about their behaviour.

Maintains appropriate classroom behaviour.

Manages disruptive behaviour among learners.

Table 2

Sample Teacher Performance Indicator:

Gives directions and explanations related to lesson content

Rating	Descriptor
1	Fails to give any directions or explanations (either written or oral) when there is an obvious need to do so.
	OR
	Directions and explanations are difficult to understand and no attempt is made to remedy the confusion.
2	Directions or explanations are difficult to understand. Attempts to clarify confusion are largely ineffective.
3	Although most learners appear to understand, the teacher works with the entire group to clarify misunderstandings.
4	Only a few learners misunderstand. The teacher identifies specific learners who have difficulty with directions and explanations and helps them individually.
5	No evidence of learner confusion about directions or explanations is evident.

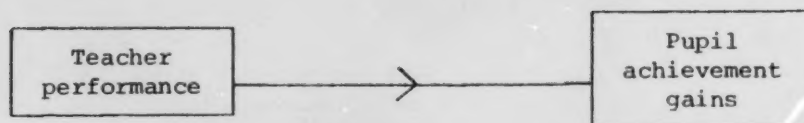


Figure 1. A model for validating teacher performance variables

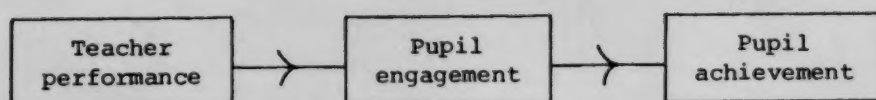


Figure 2. A model for classroom learning

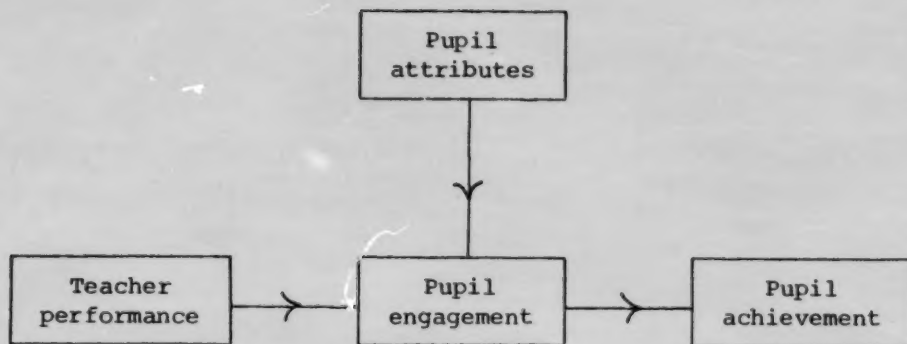


Figure 3. An expanded model for classroom learning

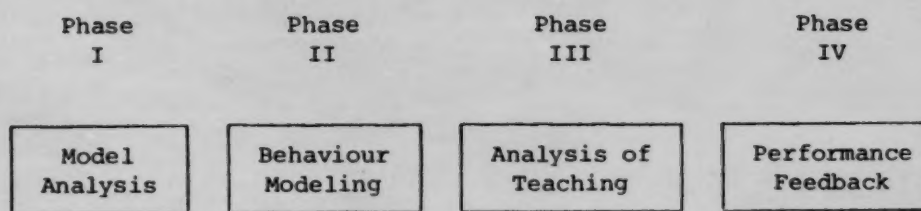


Figure 4. A model for acquisition of specified teaching behaviours

teacher
discourse

pause

teacher
discourse

pupil
discourse

pause

teacher
discourse

Figure 5. Examples of teacher wait-time

PRIMARY SCIENCE IMPLEMENTATION: THE DEVELOPMENT OF
STRATEGIES IN W.A. TO PROMOTE EFFECTIVE TEACHING

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1.0 INTRODUCTION

The current West Australian Primary Science Syllabus* was printed in 1973. This paper traces the Education Department's efforts to disseminate the Syllabus and encourage its implementation. I hope to show how our understanding of these processes has developed, by outlining where we have come from, where we are now and where we may be heading.

I should comment from the outset that I use the term 'we' in this paper to represent those people who have been or are involved in the dissemination of this Syllabus. My own involvement dates from 1978.

I wish to acknowledge the assistance of Rob Ozanne, also from Curriculum Branch, in the preparation of this paper.

2.0 WHAT DOES THE SYLLABUS SAY?

The 1973 Syllabus has two major emphases:

- (a) It emphasizes the development of *scientific thinking skills and attitudes*, and details the processes of thought and action which constitute a scientific approach to finding answers and solving problems.

In order to achieve this, and in accordance with our understanding of how children learn,

- (b) It emphasizes a *hands-on, inquiry approach*.

Because these terms have many interpretations, let me summarize them simply as an approach in which children find out for themselves from guided experiences, in contrast to an approach in which the teacher has the experiences and tells the children about them.

3.0 WHAT PROGRESS HAVE WE MADE?

In 1979, concerned about the implementation of the Primary Science Syllabus, I wrote a discussion paper which attempted to summarize where we had reached and what action might be appropriate. I said at the time that 'If an overall assessment could be made of the implementation of the Syllabus, it would have to be concluded that its effect on the learning experiences of children in W.A. classrooms has been minimal!' and that 'Teachers are ill-equipped and motivated to teach effective science in terms of the 1973 Syllabus.'

*The Syllabus referred to is *Primary Science, Syllabus with Notes, Draft Edition, 1973*, produced by the W.A. Education Department.

Now that represents a fairly pessimistic summary of the impact of a Syllabus which had been in schools for 6 years and an approach which had been promoted for 10 years. What is important is to understand why.

Reasons are identifiable. Some are due to the nature of the Syllabus; some are due to the nature of the change process; some are due to the nature of the dissemination process; and some are due to pressures and priorities within the education system.

In particular, I believe that in our attempts to encourage implementation we failed to take into account two key issues which need to be considered if change is to be effective:

- (a) Teachers need to be eased through the process of change at a rate they can cope with. They need to be assisted, step by step, to develop understanding of an innovation and the ability to implement it. Butt (1979), in detailing a programme for assisting teachers to gradually change their teaching style, comments appropriately that 'Very few innovative projects have provided teachers with the gradual step-by-step procedure necessary for making these difficult changes, even if they wish to make them. We have failed to apply two eternally sound educational principles: (1) Start from where the learner is ... and (2) Provide for learning at the learner's pace in increments that will encourage success.' (p.241) Studies by Fuller (1969) and Hall et al (1973) are valuable in their description of the stages in this process of development.
- (b) Effective change in teacher behaviour will occur only in a school climate which is supportive of change. This means that while developing teacher competencies, we also need to develop the school's willingness and ability as a unit to respond to and initiate change. In outlining strategies educational innovation, Husén (1972) pointed out that 'we cannot with reasonable success bring about change only by actions taken from above, by doing things *to* or *for* the system. If we want to achieve social (including educational) change, we are entitled to enter the system and to try strategies whereby we seek to change the system from *within*. The basic problem is thereby to make the system susceptible to change, to establish a climate which reacts positively to change.'

From our 1981 vantage point it is easy to say 'how obvious!' It is also easy when looking at dissemination strategies used during the years to criticize those involved for failing to grasp the real nature of their task and to plan accordingly. However, it is fair to say that their lack of knowledge of the change process, and experience in bringing about change prevented them from understanding or even seeing the problem. In ten years, someone reading this paper may say the same of me! It is also necessary to comment that at some stages, their actions were restricted by policies and procedures which may have emanated far beyond the science curriculum area.

4.0 HOW HAS IMLEMENTATION BEEN FACILITATED?

4.1 *Publications*

Publication of the Syllabus was preceded by the distribution of at least seven booklets (Nature Advisory Service, 1968, 1969, ...) which outlined the approach and its implications, and suggested classroom activities for teachers. A comprehensive set of Teachers' Source Books and Children's Workbooks was produced between 1973 and 1980.

It is unfortunate that these materials were not introduced to schools in a co-ordinated manner and that many teachers acquired negative attitudes towards them. However, these publications, no matter how well written, produced or promoted, can have limited impact.

For most teachers the new approach requires a change in attitude toward teaching and learning and a change in teaching style. Few teachers have the confidence and skills to successfully develop new teaching strategies, sophisticated questioning techniques and alternative classroom organization in response to what they have read. More tangible support is required.

4.2 *Advisory support*

Advisory support in the early stages failed to effectively confront the problem. Prior to 1976, curriculum/advisory personnel were located centrally. We conducted in-service and visited schools to assist teachers. At the time, the Department provided two days of in-service for all teachers every two years - at least, in theory, and excluding those in the Pilbara and Kimberleys! The amount of time allocated to Science varied from one to three hours.

Such an approach failed to recognize the needs of teachers. It assumed that showing, telling and enthusing teachers was all that was needed.

This assumption was also implicit in the establishment of *lighthouse schools*. The strategy involved the identification and development of schools with a science education programme which could be used as a model for other teachers to view.

The regionalization movement in 1976 saw the relocation of some advisors in regional centres. The frequency of both in-service and individual consultation in these regions increased. In-service was usually conducted at the regional or sub-regional centre and was available to teachers who were interested in attending and who were able to be released from their school, if the course was held during school hours.

Some advisors soon realized that two or three hours of in-service was of little value unless followed up by visits to the participants. Although there may not have been much understanding of the developmental process through which the teachers were proceeding, there was a realization that continuous contact with a teacher was more likely to achieve real results.

Regional advisors have always enjoyed considerable autonomy of operation. Regional directors/superintendents, to whom they are responsible, have generally exercised little direction over their activities, treating them as professionals, capable of deciding how to use their time and resources to maximum effect. As a result, some individuals and groups tried new approaches.

One development was the *focussing of support on individual schools*. In-service was conducted on the school site with all members of the school staff. Regular contact, in the form of further in-service and individual counselling, followed. One advisor tried working in a school for two or three weeks full-time, assisting staff with planning and teaching. Another advisor worked in a small group of schools for a half-day per week for a term. Other variations also developed.

What became apparent, however, was that real gains occurred when all, or nearly all, teachers on a staff were committed to development and remained involved; when activities followed in a logical development, and when expectations were made of teachers to try the things which were discussed or demonstrated. When these factors were present, all teachers on the staff were involved in trying the innovation at the same time, thus reducing concern about how their peers were viewing their efforts. In addition, the staff was able to develop as a unit through experiences, discussions and decision-making.

A second significant development, begun in 1978, was the *kit workshop*. In essence this was a series of 4 or 5 sessions conducted over several weeks, during which participants prepared classroom topic kits. The significance of the workshops, however, was not the product but the process. In developing a kit, each teacher had to confront many issues involved in teaching science and to find workable ways of handling them. They were then able to take away from the workshops a practical, personally-customized instant teaching kit - all they had to do was to add kids and mix!

The success of this model of in-service emphasized the value of continuous support for teachers during the preparation and testing of classroom materials. Although the model promoted teacher development, it did not ensure support for the teacher from within the school.

The school-focussed activities did enable teacher development to take place in a supportive school environment. It is unfortunate that we not only lacked an adequate understanding of teacher development, but also had limited skill in facilitating the growth of a supportive school climate.

What has evolved, however, is a model which combines the two features. In many instances, kit workshops are conducted with individual schools, on site. They are often used as a way of establishing a school equipment pool and as a pre-requisite to the later development of a whole school policy and programme.

4.3 Long Courses 1978-80

While these developments were taking place, in 1978-79, funds became available for four ten-day courses. These were led by C.A.E. staff on campus in liaison with curriculum/advisory personnel. The courses enabled real changes to occur in participants' attitudes to teaching and learning, especially when supported by advisory teacher follow-up. Because of the lack of school support, however, there were still instances where this out-of-this-world in-service experience was followed by burn-out on re-entry!

It was hoped that participants would have a significant impact on their schools. In practice, however, they were able to exercise little influence. Therefore, in 1980, some attempt was made to increase this impact by including in each course a strand which examined issues associated with playing a change agent role among peers.

There were instances where the participants catalyzed their schools and where, with the support of regional advisors, noticeable development took place within the school. Generally, however, there were three major inhibitors:

- (a) The participant's colleagues did not necessarily identify science as an area in which they were prepared to make a commitment to apply special effort;
- (b) The participants, while willing to offer assistance to anyone requesting it, did not feel comfortable with the role of change agent;
- (c) The participants did not know how to impart to their colleagues the understandings and skills they had acquired.

4.4 Principals and Key Teachers 1980-81

During 1980 and the first half of 1981 a programme of principal in-service was conducted. During this programme all principals in the State were given the opportunity to attend a one-day conference. The objectives were to clarify what Primary Science is all about and to examine issues involved in developing science in the school, including the effect of principal's expectations and support.

It was important that some follow-up support be available if a principal and their staff wanted to develop the science education programme in their school. However, in many of the country regions advisory support was not available.

In some regions the problem was answered by what became known as a *key teacher* model. Schools which were interested in developing their science education programme sent one or two teachers to a one-day in-service course, during part of which they developed and practised a workshop to present to the staff. Following the workshop the key teacher encouraged his colleagues to share their experiences and endeavoured to maintain effort and enthusiasm. They also kept in touch (usually by phone) with the curriculum officer who later returned to work with the school and to assist the key teacher further.

The model incorporated two developments:

- (a) We had come to understand far better the development of teachers in using an innovation. The intention, therefore, was that the key teacher would guide his colleagues through steps which initially focussed on lesson strategies and classroom management and later progressed to school policy and school programming.

Unfortunately, because the key teacher is trained in only one step at a time, the school's development is dependent upon continual visits from the Perth-based curriculum officer. This type of support has been limited. The model was used for a time in some metropolitan schools where the regional advisor was the external consultant. In such cases, however, the key teacher role developed in the early stages into a role of school-based motivator, co-ordinator and liaison officer, rather than advisor.

- (b) It confronted the fact that whole staff commitment, including that of the principal, to a programme of development is essential if the programme is to be effective. Before the key teacher conducted the first workshop in the school, the curriculum officer visited the school and spoke with the principal and the staff. Unless willing commitment was evident, the programme was not initiated in the school.

4.5 *Regional Resource Personnel 1981*

When funds become available for only one long course in 1981, we decided to go even further. If one of the key problems with implementation of the Primary Science Syllabus approach is in assisting teachers to acquire the competence and confidence to teach it effectively, then support both from within the school and from an external agent is essential. However, because of budgetary restrictions and subject priorities, little or no advisory support is available in most country regions. We decided to use the course to train classroom teachers to play an advisory role in their district. The role came to be known as Regional Resource Personnel or R.R.P.

If these R.R.P.'s were to be effective, however, two conditions were critical:

- (a) They needed to be trained specifically for their role as change agents.
- (b) The regional director/superintendent needed to be willing to use them in this role and to be able to release them from their school as necessary, without placing them in a position of friction with their colleagues.

The support from regional administrators was enthusiastic. Selected teachers were trained in a course which consisted of a combination of course work and planned field work.

There are now 19 R.R.P's located in the nine country regions, one in a metropolitan region and four in metropolitan independent schools. In addition, four advisory teachers, three of them newly appointed in 1981, participated in the course.

There are significant developments with this course:

- (a) Advisory support is available on a regular basis to schools which previously had no such support.
- (b) The consultants have been trained to play that role. This is a significant and exciting breakthrough.
- (c) Consultants have devised strategies for working which are consistent with what we know from our own experience and that of others to be likely to be effective. This is also a breakthrough.

5.0 WHERE ARE WE NOW?

There are many problems in facilitating curriculum implementation. It is not an area in which it is easy to establish clear principles. Most of our knowledge in the area is based upon specific experiences in specific settings - case histories - with all their attendant limitations. What I have tried to show in this paper is that I believe we have been learning from our own experiences, and that where we are now is not where we have landed by 'pin-the-tail-on-the-donkey' means, but is where we have grown to.

We still don't know the best way to promote effective curriculum implementation simply because there is no best way. What we do know however, is that there are several principles worth applying:

- (a) The teachers must identify the need for development and be willingly committed to a programme of development.
- (b) Principals' support is necessary. i.e. They are in accordance with the philosophy and approach being developed, their demands and expectations are consistent with what is being attempted, and they are willing to foster a support relationship with the teachers and a supportive environment.
- (c) Colleague support is necessary. i.e. A teacher needs the empathy of colleagues and needs to be able to share experiences with colleagues on staff. In practice, this means working with a significant proportion of a staff (rather than isolated teachers).
- (d) A planned, long-term programme of support for teachers is necessary, (in contrast to 'one-shot' or 'ad-hoc' advisor activities).
- (e) The change agent, or advisor, must have credibility. i.e. They must be perceived to have something to offer and the right to offer it.
- (f) The advisor must be able to plan development experiences which are appropriate to the real needs of the teachers and to their particular stage of development; and be able to facilitate the development of individuals and of the staff as a unit, so that the advisor can progressively withdraw.

Our progress to this stage has been supported by developments throughout the world. In recent years, there has been a growing volume of literature which has added to this understanding of the change process in schools. Referent works, such as those by Bennis, Benne and Chin (1969), Rogers and Shoemaker (1971) Havelock (1972) and Hall et al (1973), have provided the framework within which scores of case studies and developing theories and generalizations can be examined. What is interesting is to see recent articles which identify similar trends to our own approach. For example, a recent report in *Education in Science* (Education Committee 1980) recommended that continuous support should be available to primary school teachers, that more training be directed towards school principals, that schools should identify a teacher to assume a trained consultant role on the staff and that school-based in-service involving all members of staff is necessary.

6.0 WHERE DO WE GO NEXT?

Where we should evolve to next is not easy to answer. What I am about to suggest is a personal viewpoint, not one which is necessarily accepted by Education Department decision makers.

Firstly, I believe we need to improve our techniques in the two key areas mentioned throughout this paper:

- (a) Assisting teachers to develop in their skills and understanding and easing them through the process of change; and
- (b) Developing the School's willingness and ability as a unit to respond to and initiate change.

Secondly, I believe we need to improve our ability to respond to school-based curriculum initiatives. In a centralized education system there are people in authority who determine trends or emphases which they believe ought to be reflected in school curricula, and who have the power to have those emphases implemented. Teachers (including principals) constantly look to the Department for guidelines regarding recent curriculum developments in the various subject areas and for direction as to where emphases ought to lie. That interest may be educational (how can I provide my children with the best curriculum?) or career-survival (wet-finger-in-the-wind decision-making.) Most of the activities outlined in this paper involved assisting schools to implement one such trend initiated by the Department. However, a second type of curriculum development begins when a staff, together with parents, the regional superintendent and others, formulates a corporate vision of where they would like their school education programme to be, and sets out to achieve it. We need to develop the perceptions and skills to assist schools in this type of development.

Thirdly, I believe the Education Department needs to offer support for the role of science education in the total development of children. While teachers are under pressure to produce better standards in such subjects as language arts and mathematics, and while science is seen as an option or 'frill' subject, there is little incentive for teachers to develop their skills in the teaching of Science.

In achieving the support of the Department, the key figures are the district Superintendents. Some in-service work has already been done with this group and more is planned during 1981. It is hoped that activities such as this will enable the problem to be reduced.

As this paper has concentrated upon the activities of curriculum/advisory personnel in bringing about change, I would like to propose three ways in which their role might develop in the future.

- (a) Curriculum/advisory personnel need to be trained for their role.

We have assumed in the past that a successful classroom teacher is automatically able to assist teachers to develop their skills and to work together in developing the educational programme of the school. This is an untenable assumption. It is essential that advisory teachers participate in a training programme. This programme should include both course work and structured field work.

- (b) The structure needs to be provided to ensure that advisors can operate in an effective way.

In the past we have left advisory teachers to plan, or their regions to plan for them, an effective mode of operating. As an outcome of the training programme, advisors should be enabled to operate according to certain considered principles which remain consistent with our growing understanding of the change process.

- (c) Subject advisors should be replaced by general curriculum consultants.

Current curricula emphasize methods of learning to promote concept and skill development. Most teachers need assistance with:

- o information about new trends in curricula;
- o techniques and strategies for effective teaching;
- o working with colleagues in developing co-ordinated educational programmes through the school.

This assistance is largely independent of the subject area, and requires little specialist knowledge of any subject area. In the primary school in particular, since teachers are expected to teach in all subjects, it follows that advisors should be able to advise in all subjects. Maybe this way we might overcome some of the competitive pressures for time and emphasis between subject areas. The advisors would be able to convey an approach to education which is integrated in the real sense and in which the various subjects are simply convenient frameworks for planning.

Instead of subject advisors then, we should appoint curriculum consultants. These people would not be responsible for 80 schools in a region, but for a local group of (say) ten schools. Their role would be to assist schools in the continual evaluation and development of their educational programme and assist teachers in the development of their skills. Because they are external to the school and play no reporting or inspectorial role, they would be able to evaluate objectively, offer input as appropriate, have access to special resources necessary and assist the staff to develop a working cohesion.

Whether any of these changes will be achieved in the near future remains to be seen. What is clear, however, is that recent years have seen a development in our understanding of the process of bringing about change in teachers and schools, and that further developments should built upon that experience.

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FINDINGS OF THE PHYSICAL SCIENCE EVALUATION PROJECT 1978-79

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Background

In 1978 a new two-year upper school subject, Physical Science, was introduced into secondary schools in Western Australia. It was approved by both the Tertiary Admissions Examination Committee and the Board of Secondary Education. This paper is drawn largely from the final report of the Physical Science Evaluation Project¹, due to be released shortly and summarises the main findings of that report. A number of evaluation reports have already been released by the project to a wide audience including teachers, tertiary personnel and other interested parties (See Appendix 1). Of these, two are particularly relevant. One report² described the implementation during 1978 of the new course and examined a number of issues which had been important to students, teachers and others involved at that early stage. It also contained an outline of the evaluation study and of the approach used, and discussed the methods of data-gathering and reporting employed. The second report³ examined the characteristics of those students who entered the course in 1979 as the second cohort and included some comparative data relating to the first cohort who began in 1978.

Establishment of Physical Science as a new Subject

- (a) Initially, the suggestion for an alternative Tertiary Admissions Examination (TAE) subject for students who did not wish to do both Chemistry and Physics came from the Education Department in response to needs perceived within the schools. One factor influencing this was the fact that many students then studying Chemistry and/or Physics (usually in conjunction with Mathematics 2 and 3) were not proceeding to tertiary studies in these subjects. Another was the need to provide appropriate courses of study for the increasing proportion of the age group who were staying on at school beyond Year 10, but who did not have the same orientation toward tertiary studies.

¹ Dynan, M.B. and Ryan, A.S. Physical Science Evaluation: Final Report Co-operative Research Series, Education Department of Western Australia, 1981.

² Characteristics of 1979, Year 11 Physical Science Student Population, Ed. Dept. (WA), 1979

³ Physical Science Evaluation 1978, Co-operative Research Series, No. 3 Ed. Dept. (WA) 1980

- (b) Earlier consultations with academic scientists in the tertiary institutions revealed little support within this sector for such a change. However, further consultations were held subsequently through the aegis of the Secondary Science Education Curriculum Committee involving senior academics, senior officers from the Education Department, and teachers' representatives. This committee ultimately recommended the adoption of the Physical Science Course as a TAE and CSE subject.
- (c) Though it was agreed by the committee that Physical Science should provide an alternative for students who did not wish to pursue chemistry or physics at the tertiary level, there remained some ambiguity about whether the proposed course would provide an appropriate preparation for a number of science-related tertiary courses.
- (d) The agreed rationale, aims and content of the new course were based, with considerable modifications, on the one-year course Man and the Physical World which had been then recently developed in Victoria. Teachers' Guides and Student Resource Books were prepared by the Curriculum Branch of the Education Department with the assistance of specialist content consultants and contract writers.
- (e) The majority of science specialists in the tertiary institutions ultimately accepted or welcomed the establishment of the new subject. However, some senior and influential specialists were either not in favour of it, or else disliked the content of the course as represented by the first draft materials.
- (f) There was general support from school principals and science teachers for the introduction of the new subject. Most were clearly in favour of the prospect it offered for broadening the range of subjects open to their students, particularly those wishing to study chemistry and physics in a less quantitative fashion or to combine study of one of the biological sciences along with a single course in the physical sciences area.
- (g) The tertiary institutions advised schools from the outset that students wishing to take chemistry or physics courses at tertiary level should study these same subjects, rather, than Physical Science, at the TAE level. Generally, schools took this advice seriously, both in relation to adoption of the new subject, and when counselling students on entry to Year 11.

Materials Development Procedures

- (a) The procedures used for the preparation of written materials -- the use of contract writers and consultants working in collaboration with the Curriculum Branch course writers -- were seen as satisfactory by most of those involved. Nevertheless, a number of specific difficulties were encountered in the process. These included delays in getting responses from some of the consultants, all of whom were involved on an honorary basis; the difficulty of incorporating or reconciling the different suggestions and modifications proposed for some units; a lack of time in which to return modified sections to the consultants before the units were printed for use in the trial

schools; and pressures on the course writers to incorporate more reading material in the resource books than had originally been intended.

- (b) A few of the consultants were critical of the writing model used and would have preferred a contracting arrangement whereby the responsibility for preparing first drafts would be given to specialist scientists in the relevant areas. However, the majority of the consultants and teachers appear to have been happy with the writing and review procedures followed.
- (c) All of those involved in the development of the resource books expected that the trial versions would be revised for subsequent editions on the basis of feedback from the trial teachers and others involved, and saw this as a major strength of the overall process being used.

Initial Dissemination of the Course

- (a) Communication of advance information about the course during 1977 was considered adequate by almost all schools. However, the existence of better developed networks of communication within Government schools appears to have contributed to their higher rate of adoption compared to the non-Government schools.
- (b) In 1978, the first year of the trials, 18 Government schools and one non-Government school elected to offer Physical Science enrolling a total of 369 Year 11 students. In 1979 a further 16 schools (including three non-Government schools) joined the group, and the total Year 11 enrolment increased to 688 students. Table 1 shows the participation rates, in terms of total Year 11 enrolments for various Science subjects, for schools adopting Physical Science in 1978 (Group A) and 1979 (Group B).

TABLE 1 ESTIMATED PARTICIPATION RATES¹ (PERCENT OF TOTAL YEAR 11 INTAKE) FOR YEAR 11 SCIENCE SUBJECTS IN 1977, 1978 and 1979

	Group A Schools			Group B Schools	
	1977	1978	1979	1978	1979
Physical Science	N/A	11	12	N/A	11
Chemistry	25	24	24	28	22
Physics	23	21	22	25	20
Biology	52	49	45	41	40
Human Biology	36	35	33	30	28

¹ Participation rates shown are those for the 18 schools in 1978 and 28 schools in 1979 for which completed enrolment analysis forms were available.

- (c) Factors inhibiting early adoption in non-Government schools included the desire to await information on the progress of the course during the trial phase, staffing and other resource considerations, parental concern or uncertainty regarding the eventual status of the new subject, and the perceived constraints on student choices implied by advice from tertiary institutions. Nevertheless, the majority of non-adopting schools in 1978, whether Government or non-Government, were favourably inclined towards the new course and indicated that they would probably adopt it at some time in the future.
- (d) Within the first group of trial schools, science teachers played a significant part in the decision to adopt and these teachers were, for the most part, highly motivated towards successful implementation of the course.

The In-service Programme

- (a) For schools which notified their intention to adopt the course in 1978, further information was disseminated through a special programme of in-service meetings for the teachers involved. This programme, which commenced late in 1977, extended through the first two years of the trial period. All of the teachers involved in the meetings during this time found the programme to be most valuable, particularly in the early stages of implementing the course.
- (b) Though the course developers played a key role in the organisation and running of the meetings, they encouraged the teachers to take the initiative in identifying their own needs and suggesting the kinds of support they wanted. The teachers were concerned mostly with problems of organisation, depth of treatment of topics, sequencing within and between units and assessment procedures. They did not express much need for assistance in relation to teaching strategies or scientific background in relation to new science content contained within some units.
- (c) Many teachers expressed the view that, despite the flow of written information about the course, they would not have developed as full an understanding of the philosophy and general teaching approach without the discussions and interaction with the course developers and others at the in-service meetings. Another important benefit of the in-service programme was the development of strong group identification among those involved; most teachers derived considerable psychological support from the group and from the opportunities the meetings provided for exchanges of experiences.
- (d) The programme was also valued by the teachers because of the opportunities it afforded for
 - (i) continuing input from the course developers regarding the nature of the course and the details of the units being taught,

- (ii) feedback to the Education Department concerning implementation problems, and
 - (iii) feedback to the external examiners concerning the format and emphases of the forthcoming TAE examination.
- (e) Those teachers involved in the in-service found the duration of the programme adequate. However, some felt that the lack of similar support planned for subsequent years might lead to problems for incoming teachers particularly those in schools taking up Physical Science for the first time.

Characteristics of the Physical Science Students

- (a) In terms of mathematics and science backgrounds, Physical Science attracted students with a much wider range of ability and achievement than continued to be the case for Chemistry or Physics. Figures 1 and 2 show the achievement certificate grade distributions in Mathematics and Science for incoming Physical Science students in 1978 and 1979.
- (b) In both 1978 and 1979, the ratio of boys to girls enrolling in Physical Science in Year 11 was about 1.8:1. The corresponding ratios for Chemistry and Physics enrolments were each about 3:1.
- (c) Students enrolling in Physical Science were attracted by the fact that they could combine the study of chemistry and physics in one subject, thus allowing them a wider choice for their remaining subjects. Most also liked the less quantitative focus of the course and the opportunities it gave them to relate science to everyday life.
- (d) About sixty percent of Physical Science students in 1978 and 1979 also enrolled in Biology or Human Biology. There was some evidence that the introduction of Physical Science had caused a small drop in enrolments in Chemistry and Physics. However, there was also evidence to indicate that, if Physical Science had not been available, many of those taking the new subject would have chosen a non-science subject in its place.
- (e) About fifty-five to sixty percent of incoming students had intentions of continuing to tertiary studies. Of these only a small percentage planned to take courses involving one of the 'pure' sciences, though a substantial number hoped to enter science-related areas such as engineering, computing, agriculture, science teaching and various paramedical fields.
- (f) The great majority of students entering the course expressed a 'strong' or 'very strong' interest in science. While they found the subject more difficult in practice than anticipated and generally did not rate it as their most popular subject, they remained highly motivated throughout the two years of the course and satisfied with their decision to undertake it.

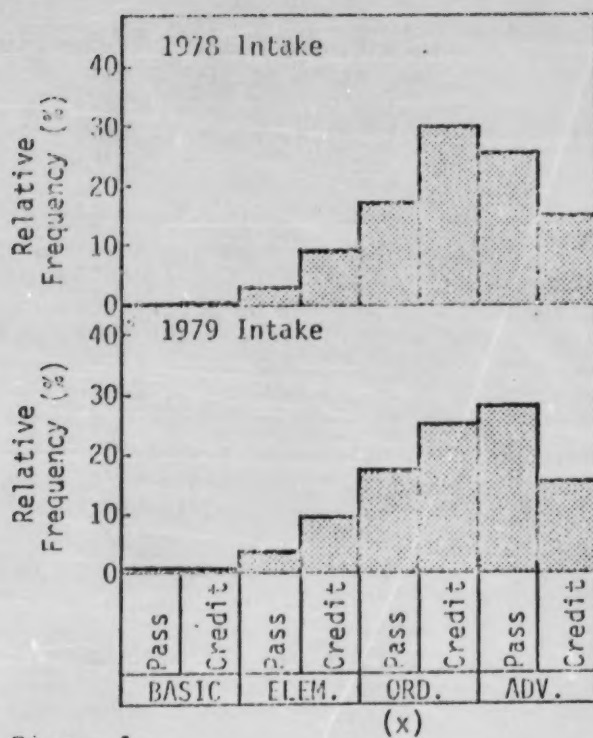


Figure 1
Year 10 Mathematics grade distributions
for total Physical Science intakes in
1978 and 1979.

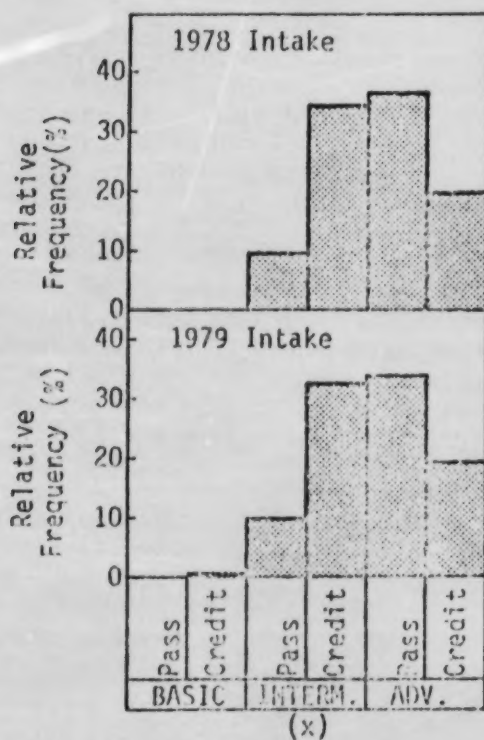


Figure 2
46
Year 10 Science grade distributions for
total Physical Science intakes in 1978

- (g) From the first cohort of Physical Science the final number to sit for the TAE examination in 1979 was 281. Allowing for the small additional intake of students part-way through the two years, the withdrawal rate was twenty-eight percent, slightly higher than the rate averaged across all two-year upper-school subjects for the State as a whole. A relatively high proportion of the withdrawing students comprised those with weaker entering backgrounds in science and mathematics.

Implementation in the Schools

- (a) Most of the schools involved had ample laboratory facilities and equipment and those special items of apparatus and materials required for the course were provided by the Education Department. Technicians were available in almost all the schools and this was an important factor in facilitating the preparation of laboratory activities and materials. One exception to this general picture was the scarcity of electronic equipment for use with two of the optional units.
- (b) Library facilities were also adequate in most cases, and teachers commonly established class-libraries for use in conjunction with the student resource books. Ample supplies of teachers' guides and resource books were available. Some delays were encountered in the production of case-study resource books though this did not appear to hamper the teachers unduly.
- (c) Only a few teachers made consistent use of audio-visual aids. One major difficulty concerned the limited access by many teachers to the recommended films, though some schools appeared to be more fortunate or better organised in this regard than were others. There were also problems with the quality and appropriateness of some of the recommended films. Teachers were later assisted to some extent by the production of guidelines on individual films by the Curriculum Branch officers.
- (d) Most of the teachers followed closely the structure and suggested sequence of topics within each of the units. They relied very much on the content and suggestions for student activities within the guides. While they encountered problems and difficulties from time to time, most of the teachers found the guides and student resource books to be an indispensable feature of the course.
- (e) Though all the teachers in 1978 commenced the year with Materials, Properties and Structures they did not all follow the same sequence through the remaining core and optional units. The majority of teachers chose the options Science and Society and Water and Other Liquids but small numbers used the other available options. Figure 3 shows the sequences planned by the first group of teachers.
- (f) In attempting to cover the content in the manner suggested in the guides most teachers soon found that they were unable to keep to the recommended time schedules. One common problem faced by many teachers was the fact that their students

represented a wide range of abilities and backgrounds. Moreover, teachers evidently found it difficult to teach the basic concepts in the less quantitative manner intended.

- (g) Both teachers and students relied substantially on the guides and resource books, and many students appeared to have considerable difficulties in using other science reference books. As a consequence most of the teachers resorted to heavier emphasis on direct teaching and preparation of supplementary notes.
- (h) In general, the teachers covered a high proportion of the suggested laboratory activities and demonstrations. Only in a small number of cases did teachers include, in a significant way, class discussion and enquiry approaches; in the main the teaching strategies used were expository. Visits to industrial sites and case-studies were used to provide opportunities for students to engage in related investigation.
- (i) Perceptions of the likely content of the first TAE paper in Physical Science played a considerable part in teachers' and students' approaches to the subject. There was natural concern about whether the paper would adequately and properly reflect the broad objectives of the course. In this regard the interaction between the examiners and teachers and the production of a trial paper proved to be valuable to teachers and students.
- (j) Some of the teachers commented on the fact that their teaching methods changed significantly during the trial period. Their understanding of the appropriate depth of treatment for particular concepts and of the relationship between various topics within the course developed with increasing familiarity with the course and from interaction and discussion at the in-service meetings. Initial anxieties about the amount of content in the course declined somewhat as the course progressed.
- (k) Most teachers used a variety of evaluation procedures as part of their assessment of students. These included periodic written tests, short tests at the end of units, essays, laboratory reports and assignments. There was a tendency in the written tests to focus mainly on chemical and physical principles and factual knowledge along the lines of typical chemistry or physics tests. However, some teachers put considerable effort into devising examples which stressed applications of science.
- (l) The presence in some classes of students who found the course generally too difficult caused anxiety to teachers; however, these students tended to leave the course in Year 11 thereby easing the difficulty for these teachers.

Figure 3 : SEQUENCES OF UNITS PLANNED BY FIRST
PHYSICAL SCIENCE TEACHERS

	1ST	2ND	3RD	4TH	5TH	6TH	7TH
TEACHER							
1	M	CC	CI	W	ET	CB	SS
2/3	M	CC	CI SS	CB	ET W/E		
4	M	CC	CI	W SS	ET	CB	SS
5	M	CC	CI	ET	SL	W	CB
6	M	CC	CI	ET	E	CB	CP
7	M	CC	CI	ET	CB SS	W/CP	
8	M	CC	CI	ET	CB	W	SS
9	M	CC	W	CI	ET	CB	EF
10	M	CC	W	CI	ET	CB	SS
11	M	CC	W	ET	CB	CI	SS
12	M	CC	ET	CB	SL	CI	SS
13	M	CC	ET	CI	W	CB	SS
14	M	CC	ET	SL	CI	CB	CP
15	M	CC	CB	ET	CI	CP	SS
16	M	CC	CB	ET	CI	W	
17	M	CC	SL	CI	ET SS	CB	
18	M	W	CC	CI	ET	CB	EF
19	M	CI SS	CC SS	ET	CB	W	

Core Units

M: Materials Properties and Structures
CC: Chemical Change
CI: Change and Interaction
ET: Energy Transformations
CB: Carbon-based Materials

Optional Units

W: Water and Other Liquids
CP: Ceramics and Polymers
SS: Science and Society
SL: Sound and Light
E: Electronics
EF: Engines and Fuels

Overall Reactions to the Course and the Written Materials

- (a) Considerable interest in the innovation by tertiary scientists was indicated by the variety and strength of reactions to the first trial editions of the guides and resource books. In general the content of the materials and their presentation tended to reinforce previous attitudes, either favourable or unfavourable, towards the course itself.
- (b) Aspects of the content of the written materials which generally received favourable comments from a majority of tertiary scientists and consultants included:
- the strong emphasis on laboratory activities integrated throughout the units.
 - the many attempts in the materials to relate the science concepts to practical applications in industry and everyday use.
 - the inclusion of studies of materials including alloys, ceramics and polymers either in core or optional units.
 - the wide range of topics relating to modern applications of science.
 - the inclusion of studies of the social impact of technology.
- (c) Aspects of the materials which evoked unfavourable reactions included:
- unnecessarily complex treatment of some concepts.
 - the choice, in some units, of industrial applications which were either outdated or less relevant than possible alternatives.
 - perceived inconsistencies in material used in different units.
 - perceived weaknesses in the linking of sections within some of the units.
- (d) Many physicists commented on the imbalance of physics and chemistry concepts within the materials and suggested that this required some future modifications.
- (e) In general the reactions of Physical Science teachers and students towards the course and the content of the written materials was very favourable throughout the two-year trial period. Aspects of the course which were most attractive to the teachers and students included:
- the opportunity it provided for a broad and integrated study of chemistry and physics.
 - the relevance which students perceived the content to have to the world around them.
 - its emphasis on interesting practical activities throughout.

- its reduced emphasis on quantitative treatment.
- the opportunities it offered for exploring issues related to the societal implications of science.
- the attractive or interesting content of many of its core and optional units.

(f) Aspects of the course which caused problems to students included:

- the rapidity with which new concepts had to be assimilated in some units.
- the perceived overload in the amount of material to be covered in the scheduled time; this led to some cramming to the detriment of practical activities and discussion strategies.
- the inability of students to obtain an overall picture of some of the content of units; they felt that the content "jumped-around" in some units.
- uncertainty in the interpretation of the stated outcomes in some sections of the course; teachers were unsure about the appropriate depth of treatment for some of these outcomes.
- disappointment among some students (and teachers) at the relative preponderance of chemistry in the course.
- perceived lack of suitable reading material in the resource books; students, on the whole, were not effective in using other science text-books or references.
- relative difficulty of some units e.g. Chemical Change in comparison with others; both students and teachers would have preferred a more consistent level of difficulty across the different units.

(g) Most teachers and students felt that the course was generally quite difficult. Because of the more qualitative approach adopted it was seen as being somewhat easier than Chemistry or Physics but, in other respects, conceptually very challenging.

(h) Teachers made a number of suggestions for improvement of the written material including:

- possible re-structuring of the units so as to incorporate the 'Science and Society' option within core units.
- adoption of a loose-leaf format for the resource books so as to enable students to add further resources.

They also made a wide range of suggestions for minor modifications to the materials (e.g. in relation to outcome statements, guide questions and audio-visual materials).

(i) Among suggestions made by the students for improvement of the resource-books were:

- improved readability of the supplementary readings.
- clarification of the sequencing within sections of each unit.
- revision of some of the less meaningful laboratory activities.
- additional guidance in relation to the required knowledge and competencies for assessment purposes.
- improvement in the visual presentation of the materials.

(j) While there was naturally continuing interest and at times concern about the form and content of the forthcoming first TAE paper, the general reaction of teachers to the paper, when it was released, was positive. They felt that it was designed in an appropriate fashion to match the overall aims of the course. Some teachers felt that there had been too little emphasis on basic quantitative skills within the questions but this was not a majority view.

Concluding Comments

The scope of this evaluation study covered the initial two years of the implementation of the new course and did not seek to include subsequent developments. A number of issues relating to the future implementation of the course were raised in comments and discussions by many of those involved at this initial stage. For example, many were of the view that the performance of the first cohort of Physical Science students in their subsequent studies or career choices would be an important determinant of the eventual status and success of the new subject¹. Interest still remains in relation to the adoption pattern within schools, with particular reference to the major independent schools. Speculations have been raised about the longer-term effects of Physical Science within the school curriculum in relation to enrolment patterns in other science subjects. Suggestions have been made to the effect that some of the innovative teaching approaches incorporated in Physical Science, as well as some of the newer content, may gradually affect the teaching of Chemistry and Physics in the schools. One principal, already dissatisfied by what he perceived as an "elitist" approach in the latter subjects, feared that the innovation would simply reinforce the emphasis on academic theoretical concepts within Chemistry and Physics.

¹ Data on subsequent career choices made by these students are contained in a supplementary evaluation report: Dynan, M.B. A Further Study of Aspects of the Implementation of Physical Science, available from the Centre for the Study of Teaching, Faculty of Education, WAIT. (1980).

Clearly, two years in the life of a major curriculum innovation of this type is too short a period on which to base final judgments. The implementation of the new course is still at an early formative stage. Nonetheless, it is generally believed by most of those involved that the new course is already firmly established in the system. There is little feeling among participants that the dissemination or implementation processes have faltered in any significant way. On many of the implementation issues summarised in this paper, action has already been taken by those concerned to meet difficulties or expressed concerns. Plans are already under way within the Education Department's Curriculum Branch to produce up-dated editions of the teachers' guides and student resource books, taking account of the various evaluation reports of this project as well as a range of other inputs.

However, it is recognised that the next few years will provide a clearer picture of the innovation's eventual success, whether that be measured in terms of adoption rate among schools or in terms of its impact on the nature and quality of science courses in schools. It remains to be seen whether the introduction of the new subject will make a significant difference to the prevailing patterns of subject choice by the more able group of upper-school students. Finally the pattern of tertiary (and other) careers followed by the first cohort of students to complete the course and their performances in these careers will be watched with considerable interest by those associated with the innovation.

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APPENDIX 1

LIST OF REPORTS PRESENTED TO SCHOOLS BY EVALUATION PROJECT

- Report on Preliminary Findings from Student Questionnaire No. 1 - Aggregate Data
- Report of Preliminary Findings from Student Questionnaire No. 2 - Own Individual School Data (Confidential)
- Enrolments in Science Subjects, 1977-78.
(Aggregate Data and Confidential Individual School Figures)
- Aggregate Summary of Responses to Teacher Report Form No. 1 ("Materials - Properties and Structure")
- Aggregate Summary of Responses to Student Questionnaire No. 2 ("Materials - Properties and Structure")
- Summary of Responses to Student Questionnaire No. 2 ("Materials - Properties and Structure") Confidential - specific to own individual school.
- Characteristics of 1978 Physical Science Student Population
- Summary of Responses to Student Questionnaire No. 3 "Chemical Change"
- Summary of Responses to Teacher Report Form No. 2 "Chemical Change"
- Summary Responses to Teacher Report Form No. 4 "Change and Interaction"
- Summary of Responses to Teacher Report Form No. 3 and Student Questionnaire No.4 "Water and Other Liquids"
- Summary of Responses to Student Questionnaire No. 5 "Change and Interaction"
- Summary of Responses to Teacher Report Form No.1 "Materials - Properties and Structure"
- Summary of Responses to Student Questionnaire No. 2 "Materials - Properties and Structure"
- Summary of Responses to Teacher Report Form No. 5 "Energy Transformations"
- Summary of Responses to Student Questionnaire No. 6 "Energy Transformations"
- Summary of Responses to Student Questionnaire No. 7 "Science and Society"
- Summary of Responses to Student Questionnaire No. 6 "Carbon Based Materials"
- Summary of Responses to Student Questionnaire No. 8 "Carbon Based Materials"
- Physical Science Evaluation 1978: Co-operative Research Series

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Fremantle Education Centre

The purpose of this paper is to briefly describe the Commonwealth Schools Commission's Education Centre Programme and the role that Education Centres may play in teacher in-service and professional development in Western Australia with special reference to science teaching. During the past decade there has been an increased involvement of science teachers in curriculum development in the schools; at the same time there has been a growing practice of mixed-ability grouping and more attention to teaching methods which stressed inquiry and investigative methods. As described elsewhere (Betjeman, Dymond & Schock, 1979; Hawes, 1979; Light, 1979 and McKenzie, 1979) the related tendency has been for a greater emphasis than in earlier times to be placed on teachers' continuing professional development. In many cases this has called for science teachers to take responsibility for their own in-service.

This paper contends that Education Centres are in a unique position to contribute to the professional development of science teachers in Western Australia.

The Education Centre Programme

An excellent comprehensive account of the establishment, maintenance and activities of Education Centres has been prepared by Cameron (1978) for the Commonwealth Schools Commission. Before the development of Education Centres in 1973 there had been few opportunities for teachers to initiate or be involved in the planning of their own in-service education courses. With the establishment of autonomous Education Centres it was hoped that this situation would be remedied.

In short, the Commonwealth Schools Commission's original intention in setting up the Education Centre programme was to test how effective Education Centres would be in promoting 'teacher-initiated' In-service activities (INSET). The Commission sought to promote the idea of control of autonomous Education Centres by teacher-dominated management committees, and wished to establish a model for further developments.

As indicated, the principle object of the establishment of Education Centres was to be the extension of the professional competence of teachers. It was envisaged also that Education Centres would serve as the base for the production of local resource materials and as social centres. The Commonwealth Schools Commission hoped that all Education Centres would serve the major aim of stimulating educational initiatives from the teaching profession and of raising the level of professional competence among teachers. It was recognised that this aim may be pursued by a variety of methods and different activities; for example, some Centres may concentrate more on courses for teachers, some on schemes of mutual practical assistance or curriculum workshops, while others dealt more with activities involving students or members of the community. Education Centres were expected to vary their relationships to schools, to other institutions, to the general community, and ways in which provisions were made for community involvement.

Recently the autonomy of Education Centres has emerged as an important issue. In his report, Cameron (ibid) indicated that Education Centres should be able to operate outside the constraints imposed by the traditional bureaucratic rules that apply to the use of funds by other educational institutions and should be free of the traditional authority and power structure which can constrain innovation and prevent participation in educational decision making by a wide cross section of teachers and other members of the school community. Cameron (ibid) advocated that Education Centres should provide opportunities for teachers to learn skills associated with management and planning related to the use of resources. Centres also should be capable of responding quickly and efficiently to the professional needs of local teachers and foster interaction between teachers and other members of the community.

The Fremantle Education Centre

The Fremantle Education Centre was the first to be established under the Education Centre Programme when a local group of interested persons made a successful submission to the Commonwealth Schools Commission in 1973. The proposed site of the Centre was a derelict building, dating from 1901, which was obtained on a peppercorn lease from the Public Works Department. It was completely renovated in 1975 with the aid of a grant from the National Estate Department. The Fremantle Education Centre is located in the Princess May Building in Fremantle.

The six objectives of the Fremantle Education Centre, as listed in the original Constitution, were:

- . To facilitate the continuous professional development of teachers;
- . to provide an open environment in which the exchange of educational ideas may lead to the development of teacher-initiated innovations in schools;
- . to encourage and facilitate inter-action between teachers and the community;
- . to familiarise and encourage participation of parents and members of the general community in educational ideas, activities and developments;
- . to establish and maintain a community educational resource centre;
- . to establish communication links with the country areas which do not at present have access to Education Centre facilities.

The Interim Council of the Centre which initially drew up the successful submission, consisted of primary and secondary teacher representatives from all types of schools, school principals, Teachers' College lecturers, and parents. The Constitution allows for Council representation from the W.A. Education Department, Catholic Education Commission of W.A., Association of Independent School, Primary and Secondary School Principals Associations, Fremantle City Council, and Tertiary Institutions. Teachers however, must always be in a majority.

Since its inception in 1973, the Fremantle Education Centre has tried, with varying degrees of success, to offer a range of programmes and activities to meet the needs of members of local school communities, with special reference to the teachers. This is being achieved through gradually creating an awareness in primary and secondary schools and tertiary institutions of the broad range of the Centre's resources and facilities. People in the community are also being encouraged to provide assistance to teachers in educational programmes, substantially on a self help basis.

Although earlier personnel involved with the Fremantle Education Centre had strong views on the role and function of teacher inservice activities at the local, State and National levels, this role was not always fulfilled.

An early report from the Centre (Fremantle Education Centre 1977) stated that:

"It has been difficult to obtain from teachers in Western Australia the degree of enthusiasm for and commitment to teacher development programmes which the initial Council of the Education Centre had anticipated would be forthcoming:... In any case, many factors (not the least of which is the sceptical attitude of many in Western Australia to 'in-service' programmes) account for the hesitant approach of many teachers to any teacher development project however exciting and realizable it may appear to be to the innovators. Modifying attitudes is a slow process, and it has taken time for teachers to familiarise themselves with the Education Centre concept and to understand the many ways in which an Education Centre can offer them professional support".

Less than twelve months ago a review of the four Education Centres in Western Australia - Fremantle, Geraldton, Albany and Derby - was undertaken by a panel of educationalists at the invitation of the Director General of Education, following a request from the Chairman of the Commonwealth Schools Commission. The Review Panel (Vickery 1980) reported that:

"Prior to 1974, teacher initiatives in their own professional development were characteristically limited...though funds made available since then through the Schools Commission have encouraged the growth of teacher initiative, the tradition is changing slowly".

The Report goes on to say:

"It is appropriate to state at the outset that the fact of survival of the State's centres since their inauguration is, in the view of the Panel, commendable in the light of the constraints and problems they have faced during the last six years. The vision that created them was, and still is, a bold and courageous one; the commitment and work of successions of local teachers and others that has supported them merits admiration".

In-Service Education and Training. (INSET)

One of the major focuses of the Fremantle Education Centre is to encourage teacher participation in school-focused, self-help, professional development in-service activities. Recent work by the Organisation for Economic Cooperation and Development/Centre for Educational Research and Innovation (O.E.C.D./C.E.R.I.) (Laderrière 1981) indicates a general under-estimation of the importance of meeting the In-service Education and Training (INSET) needs of teachers, as one of the key factors affecting educational change.

One exciting, recent approach to INSET which best describes the approaches adopted by the Fremantle Education Centre is 'School-Focused' a form of INSET which Howey (1980) had defined as:

"those continuing education activities which focus upon the interest, needs and problems directly related to one's role and responsibilities in a specific school site."

As strategies for teacher INSET become more widespread, the question of who controls INSET assumes increasing importance. The lack of clearly defined institutional bases and organisational support systems together with the too often theoretical approach to practical INSET problems, are thought to have increasingly caused teachers not to seek participation in educational decision-making and INSET opportunities. If the main aims of INSET are seen to be concerned with the improvement of teachers' classroom performance, then it makes sense to try and motivate teachers to request some control over the rate and direction of change of their own careers. Teachers need continuing INSET if they are to respond professionally and constructively to legitimate pressures to change. Accordingly, it may be argued that INSET should be given priority over pre-service education and training if necessary; this does not mean automatic, compulsory INSET but rather that some system of incentives should be designed.

Traditionally, INSET has been the poor relation of the teacher-training trio: pre-service, induction, in-service. Skilbeck (Skilbeck 1980) however, has expressed his sincere belief that greater attention must now be paid to increasing the number of INSET opportunities, especially for mid-career teachers.

Commenting on the recent Report of the National Inquiry into Teacher Education (Auchmuty 1980), he said that it was no accident that in-service had been placed before pre-service and induction. This departure from the usual order was a further attempt by the Committee (of which he had been a member) to place greater emphasis on this vital area of educational concern.

INSET and the Fremantle Education Centre.

The successful integration of four key factors - INSET INNOVATION, TEACHER, SCHOOL and COMMUNITY - is essential if teachers are to develop a positive attitude towards their own continuing professional development. Increasing public interest in and accountability of teachers means that traditionally held attitudes and values are being drastically reviewed. The social structures of school systems are constantly readjusting to changes in the political and economic climates and changes in the patterns of teacher supply and demand. The implications of falling school enrolments are becoming significant in determining future teacher/learner strategies in schools, the complexity of which is aggravated even more by the unfortunate 'scape-goat' role which Education traditionally plays; the current trends in youth unemployment are an example.

Consequently, if the present teaching force is to remain a viable educative mechanism, there must be adequate opportunity to allow its members to adjust to these rapidly changing fundamental situations. Simply providing a range of institutionalised training activities or teacher-proof curriculum guides is not sufficient to guarantee even a minimum level of professional renewal unless in making such support available, the teachers are able to exert a personal influence in matching their own wants to prescribed needs. A mis-match of such provision can be an extremely costly and wasteful exercise.

Thus it is increasingly important that teachers are encouraged to become partners with their employers in formulating strategies aimed at maintaining high efficiency within what inevitably seems to be becoming an 'aging' profession. This is where the Education Centre at Fremantle can play an important role by encouraging teacher-managed school-focused in-service innovations which involve selective inputs from the local community. The distinction between this and school-based activity is fundamental; the essence of the school-focused approach being the establishment of a process designed not to take place specifically in the school, yet the benefits of which are aimed at increasing the effectiveness of the functioning of the school, through affecting the role of the teacher as an agent of curriculum change.

The Fremantle Education Centre is currently attempting to fulfill the role of generating and sustaining teacher motivation towards in-service innovation. Generally for INSET activities, two approaches can be taken: either the teacher is given professional education and support so that he/she as a person is better able to find solutions to the changing situation in which he/she must operate; or the teacher is provided with training so that he/she as an employee is instructed what to do and how to perform.

Although most people tend to favour the first approach as being more desirable, it is supposed (Davis 1980a) that the second approach is more common. The most probable reason for this is the institutionalisation of INSET provision and the creation of an elite body of professional course-givers, giving the organisation of courses priority over their planning. If it is not the teacher who does the planning, then he/she is reduced to the role of an employee and the opportunity for teachers to be influential in shaping their professional renewal is lost. The Fremantle Education Centre is not in a position to provide training as such. Consequently, the involvement of the Centre in in-service and professional development process concentrates on the role of support for self-help initiatives (Davis 1980b).

Science Teaching and the Fremantle Education Centre.

The Fremantle Education Centre is in a unique position to foster educational initiatives by science teachers due both to its ability to operate outside the traditional authority and power structures of Western Australian education and its capacity to respond quickly to the professional needs of teachers.

Common to many of the Centre's present initiatives is the belief that the science teacher is a key disseminator in the curriculum development process and that he or she can become more effective if he or she is encouraged to take an active rather than passive role. Therefore, the Education Centre acts, as one of its functions, as an agent for dissemination. Materials, resources, knowledge and skills are available through the Centre from local, interstate and overseas agencies as well as Colleges of Advanced Education, community bodies and other curriculum centres. It is a task of the centre to disseminate these resources to teachers in schools. By virtue of the size of its budget and staff, the centre attempts this task selectively.

During the past twelve months, the Fremantle Education Centre has been involved with the dissemination of science materials produced through the Curriculum Development Centre in Canberra. Specifically these science materials are the New Zealand Primary School Science curricula (N.Z.P.S.S.) and the Environmental Education Project for lower secondary and upper primary schools. While most nationally planned and initiated innovations tend to follow the traditional research development and diffusion model the Fremantle Education Centre is able to develop project plans according to the needs of the clientele in question. In the role of disseminator of tried and tested materials such as NZPSS and Environmental Education Project, the Fremantle Education Centre initially sought to gain reaction from a small group of teachers concerning the input and uptake of the materials before progressing with more involved and higher risk activities. Subsequently the Fremantle Education Centre has been developing a model or a plan to disseminate curriculum materials, which has also involved the West Australian Services and Development Committee.

Initially, school contacts were made with individual teachers who were requested to work with the New Zealand Primary Science materials and provide feedback as to the curriculum materials' usefulness in fulfilling the schools' and the teachers' goals for teaching science. Staff from the Fremantle Education Centre visited each school on a regular basis and contributed ideas and information as necessary. Early in the dissemination process the suggestion of teacher workshops with teachers in their own school was addressed; this tended to occur on an individual basis without being artificially contrived. As a result of the positive feedback to the New Zealand Primary School Science materials it was decided to offer a series of workshops which would be open to primary school teachers in the Fremantle area. The planning and organisation of these workshop sessions was undertaken by the Fremantle Education Centre staff, and several of the teachers who were initially approached agreed to lead workshop sessions.

The teachers who attended the workshop session were the creative and imaginative types who, in the neutral atmosphere of the Centre (which is not accountable to either the Education Department or any other educational body within the State), appeared to enjoy the experience of working together and sharing ideas, successes, frustrations and expectations about teaching science. Staff of the Fremantle Education Centre have continued working with these teachers to encourage them to function as liaison persons in their schools; several teachers have offered their services and experience in science teaching in subsequent workshops

The Fremantle Education Centre is capable of offering a support role to science teachers in both government and non-government schools. Part of this supportive role is to provide additional resources in the way of both physical materials and texts. This is not to say that the Fremantle Education Centre should become a resource centre, rather it is suggested that the Centre can help by obtaining additional resources which are made available for teachers who are in contact with the Centre either through dissemination projects or other involvements.

Care is always taken to avoid duplicating those services which are available to science teachers from the Education Department's S.W. Regional Resource Centre.

A review of the literature on INSET illustrates the value of in-service education. How long the present style of Education Centres will remain as part of the Australian educational scene is currently debatable. However, experiences during the past year have shown that the freedom of action mandate with regard to management and organisation allows for a careful system of checks and balances to be set up. Education Centres in general, and the Fremantle Education Centre in particular, are in a position to respond to the needs that are brought to their attention, with the only restriction being that of financial resources and staff. Further, and this is part of their establishment, Education Centres are capable of working across systems; the Fremantle Education Centre has been encouraged to do so, and pleasing results are being achieved through working with teachers from both government and all types of non-government schools. The Centre enjoys the full support of both the Education Department of W.A. and the Catholic Education Commission of W.A.

In conclusion, it would appear that despite the severity of recent cuts in education budgets which have caused, for example, the demise of the Educational Research and Development Council (ERDC) and the Commonwealth Schools Commission Innovations Programme, and seriously threatened the future of the National Curriculum Development Centre, (CDC), the Federal Minister recently saw fit to continue funding to the Education Centre Programme for a further period (Fife 1981). It seems therefore, that through the vision expressed in the Karmel Report (Schools Commission 1973), teachers in Australian schools still have the opportunity to influence their own professional development through Education Centres in ways which are being increasingly denied to colleagues elsewhere (Bolam 1978).

Can we science educators afford to miss such an opportunity?

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GETTING ALONG WITH THE SCIENCE TEACHER:

DOES IT REALLY MATTER?

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All of us went to school. All of us remember our teachers, or at least some of them. Because memory tends to be selective, we probably remember more readily the best and worst of our teachers - the ones who made our lives as students relatively comfortable or uncomfortable. Those of us who went back to school as teachers will remember at least some of our students. Again, our selective memories probably enable us more readily to remember the students who made our teaching lives relatively comfortable or uncomfortable. All of us have experienced the teacher-student relationship from at least one side, and all of us probably have an answer, even if intuitive, to the question posed by this paper. "Getting along" with your teacher, or "getting along" with your students, has to do with the quality of teacher-student relationships, and most of us would agree that it is more comfortable for both sides when these relationships are harmonious. But what if they are not? Does it really matter if students and teachers don't get along?

The answer to this question must consider the consequences for students of not 'getting along' with their teacher. Unfortunately, shifting the focus on to consequences doesn't produce an immediate answer to the question, because it is not clear just what these consequences are. This is due not to a shortage of classroom research, but to the directions the research has taken. Research in classroom processes typically has concerned itself with the quality of teaching, and, by using student outcomes as its measure, sought to specify the determinants of quality. Early research assumed effective teaching to be a result of personality traits or characteristics of the teacher, and tried to identify these traits, but without great success (Barr, 1948). Researchers then began to look into classrooms, exploring the relationship between aspects of the teaching process and student outcomes.

One approach of this process-product research observed and analysed teaching behaviour, attempting to uncover those teaching skills which resulted in gains in student learning (see, for example, Flanders, 1963). Another approach investigated classroom environment, and by using students' perceptions of various psychosocial aspects of the classroom, endeavoured to ascertain which of these aspects influenced student learning (see, for example, Anderson & Walberg, 1974). Until recently, neither approach produced clear-cut findings of teaching or

classroom variables strongly and consistently related to student outcomes. A major criticism of many of these studies, and probably the reason for their disappointing results, concerns their methods of analysis. In a major review, Rosenshine (1971) found that most reported studies used the class as the unit of statistical analysis to investigate the effects of teacher behaviour. This assumes that teacher behaviour affects all students equally, a clear contradiction with a consensus of research findings identified by Good, Biddle and Brophy (1975), that teachers are perceived differently by students, and they have different effects. Berliner (1976) put the problem succinctly when he wrote:

By not focussing on the individual aptitudes, styles, personality and traits of students, the effects of teachers (and curricula) are masked, thus making it almost impossible to establish empirical relations between teaching behaviour and student outcome. (p.10)

Over recent years, classroom research has been shaped by advances in three areas, each of which recognises the importance of the student's individuality in the teaching-learning process. First, teacher effectiveness now tends to be viewed as a repertoire of competencies (rather than a few effective behaviours which earlier research had tried to identify) with an emphasis on the ability to deploy these competencies appropriately (Medley, 1979). Such deployment involves taking into account individual student characteristics. Second, the key variables now associated with student learning are "content-covered" and "time-on-task" (Rosenhine, 1979). The student's time-on-task, or academic learning time, is viewed as a mediating variable between teacher behaviour and classroom characteristics, and the student's achievement in that particular content area (Berliner, 1979). For instance, teaching skills relating to classroom organisation and management, commonly found to be correlates of student achievement, are important because they increase student's time-on-task. Studies of time-on-task usually emphasise cognitive outcomes, and it is appropriate at this point to record a reminder by Peterson (1979) that cognitive outcomes are not all that schooling is about, and teaching methods which increase time-on-task may not be the most satisfactory method of instruction for all students. Third, research in the traditional structuralist sociological perspective has come to be complemented by research based on an interactionist perspective. Doyle (1977) has argued the importance of naturalistic studies of classroom ecology in helping to conceptualise how teaching can be effective. In this vein, Jackson (1968) and Nash (1974, 1976) have provided important insights into schooling through the eyes of the student, especially with respect to student opinion and reaction to teaching and learning. Increasingly, recognition is being given to the input students have in determining what goes on in classrooms (see, for example, Brophy, 1976).

These current views about teaching have clear consequences for classroom research. No longer can the relationship between teacher behaviour and student outcomes be treated as directly causal. Instead, student-related variables are assumed to mediate the teaching-learning relationships. Further, more attention must be given to affective student variables such as attitudes, perceptions and emotions about schools, teachers, teaching and learning. Although much research has been confined to cognitive

variables and outcomes, the significance of affective outcomes and affective components of the classroom have been acknowledged. Good et al (1975) reviewed classroom research at the high school level and concluded that student learning gains are closely related to the general climate of learning existing in schools which is linked to variables like teacher expectations and teacher relationships with students. Affective teacher variables such as gaining student respect and forming good relationships with the student seem to be particularly important. Despite the importance these findings attach to the teacher-student relationship, research has little to say about how these relationships are formed, how they are viewed by teachers and students, and how they can affect the behaviour and performance of both teachers and students.

This paper contends that the teacher-student relationship is an important affective component of classroom life. Its purpose is to illuminate one aspect of the teacher-student relationship by focussing on students' perceptions of their relationship with their teacher, and how these perceptions are related to various cognitive and affective outcomes. The teacher-student relationship is viewed in terms of whether or not students feel they get along with their teacher. Because the study confines itself to high school students in science, it is these students' perceptions of how well they get along with their science teacher which are examined concomitantly with their cognitive and affective outcomes, specific to science.

Getting along with the teacher : what does it mean?

Research on teacher-student relationships has usually focussed on teacher expectations, attitudes and behaviour towards pupils, and how these expectancies influence student outcomes (see, for example, Brophy & Good, 1970). Because of the emphasis on teacher expectancies and attitudes in process-product research, advances in understanding teacher-student relationships from the students' viewpoint have come from interactionist approaches to classroom research. In particular, the work of Nash (1974) provides something more than intuitive insight into the notion of getting along with the teacher.

Nash used a modified repertory grid technique to develop a set of bipolar constructs to describe relevant characteristics of teachers. He first asked students to divide their teachers into two groups, those they "got on with" and those they did not "get on with", then, using a structured interview, backed up with classroom observation, he was able to elicit from students the concepts that they used to think and talk about teachers.

The six constructs Nash found were "keeps order - unable to keep order"; "teaches you - doesn't teach you"; "explains - doesn't explain"; "interesting - boring"; "fair - unfair"; "friendly - unfriendly". He goes on to use these constructs to discuss what, in the student's view, is appropriate teacher behaviour and how these students' expectancies help establish the norm for both teacher and student behaviour in the classroom. By implication, and according to students' perceptions, teachers with whom

students get on with, and teachers with whom they don't, can be described by opposite ends of the bipolar constructs.

The six constructs defined by Nash (1974) are consonant with other research about what students think of teachers. Such research usually compiles a list of qualities students favour in teachers and that "good" teachers possess. Rath (1964) describes and discusses one such list. A review by Hargreaves (1972) found that students take into account three distinct aspects of teacher behaviour, relating to discipline, instructional style and personality. Nash (1976) emphasises that these views of the characteristics of a good teacher are held by virtually all children, irrespective of their attitudes and behaviour in school. But while students may agree about what characterises a good teacher, they do not necessarily agree in their evaluation of a particular teacher. Such evaluations tend to be idiosyncratic to both students and teachers. Consequently, not all students will say they get along with all of their teachers.

For the purposes of this study, getting along with the teacher is a global term for the quality of teacher-student relationships as perceived by the student. If teacher and student get along well, then a low level of conflict is expected between them, the student would be cooperative and willing to accede to the requests of the teacher in the classroom. When teacher and student do not get along, then conflict would occur more frequently, with the student often uncooperative and unwilling to accede to the teacher's wishes. An intermediate situation, with occasional conflict, and the student mostly cooperative but sometimes slow to respond to the teacher's requests, is envisaged. Possibly the majority of teacher-student relationships are in this category. In this case, it may be the minority of students in the extreme categories who provide the contrast in any effects due to the different qualities of teacher-student relationship.

Getting along with the teacher : some possible effects

Potentially, both cognitive and affective outcomes of science teaching may be affected by whether students get along with their science teacher. As noted earlier, most research seems to show that the teacher variables associated with cognitive gains are classroom managerial skills and a method of instruction which maximises time-on-task (Good, 1979). This suggests it is the noncognitive student outcomes which may be more dependent on teacher-student relationships, although, if teacher and student do get along, it will be easy for the teacher to persuade the student to work on the task in hand, thus enhancing his chances of cognitive achievement.

The noncognitive outcomes which have received most attention in the literature are the student's attitudes to school, to the particular school subject, and to himself as a learner. These three categories of affective outcomes are considered by Bloom (1976) to be influenced by cognitive outcomes and to become increasingly interrelated as schooling progresses. Because this paper is interested specifically in the science

students' perceptions of the science teacher-science student relationship, the affective variables of particular importance are the student's attitude to science as a school subject and his academic self-concept, specific to science. These seem more likely to be influenced by the student's relationship with his science teacher than the more global variables of attitudes to school and general academic self-concept. Bloom's (1976) work suggests that achievement in science would be the cognitive variable most closely related to these affective science variables.

Research on student achievement and attitudes has touched upon teacher-student relationships in the science classroom, but the main body of research has examined the effectiveness of various teacher and instructional variables, and, by averaging student outcomes over classes, or courses, has reported very modest relationships. Despite the evidence that aptitudinal and personological aspects of the individual student are important and are likely to interact with instructional variables (Power, 1972; Gardner, 1974), few studies have taken this into account. Even when studies have focussed on teacher-student relationships, it is the teacher's interaction with the class, rather than its individual members, which is usually measured. It is uncommon to find instances where students are asked about their relationship with their teacher. When they are given a say, students have emphasised the importance of the quality of teacher-student relationships in judging their best and worst science classes (Cooper & Petrosky, 1974) and in developing positive attitudes to science (McMillan & May, 1979). In a more empirical study, Ormerod (1979) asked students to indicate whether they liked, disliked or were uncertain about their science teacher. He found generally positive correlations between liking teacher and attitude to science as a school subject when students were grouped according to sex, type of school attended, and type of science subjects. Even from this limited information, it seems clear that students' attitudes to science are related to teacher-student relationships.

A large section of educational literature concerns self-concept and related variables, such as self-esteem and locus-of-control. Many studies have correlated these variables with achievement, usually finding positive relationships, especially in secondary school. A recent meta-analysis of the relationship between measures of self and performance/achievement (Hattie & Hansford, 1980) reported a mean correlation of .27 between these variables, compared with .20 at the primary level. Twelve studies relating self to science performance/achievement had a mean correlation of .24. Again, however the importance of teacher-student relationships in the development of academic self-concept has been highlighted by interactionist researchers, such as Nash (1973, 1976). His work provides evidence that a student's self-concept is strongly influenced by the teacher's perception of him. He found teacher's perceptions were closely related to the student's academic ability and classroom behaviour, and since the student's perceptions of his own ability and worth are derived primarily from comparisons between teacher evaluations of himself and his peers (Dreeben, 1968; Jackson, 1968; Bloom, 1976) it is easily seen how teacher perceptions can affect student's academic self-concept. One study providing empirical support for these propositions is that by Peck, Blattstein, Blattstein and Fox (1980). In

an investigation of sixth grade students' ability to "cope" in the classroom, they found teacher ratings of coping ability to be better predictors of student achievement on standardised tests, attitudes toward school and self-esteem than either peer ratings or student's self-appraisals. The behaviour rating scale used by Peck et al (1980) included one item to measure the student's ability to get along with teachers, but unfortunately no results specific to getting along with the teacher were reported.

On the basis of this brief discussion, it is suggested that getting along with the teacher has both cognitive and affective correlates. More specifically, this study proposes that the student's perceptions of how well he gets along with his science teacher will be related positively to his achievement in science relative to other members of his class, his attitudes towards science at school, and his academic self-concept, specific to science.

Design of the study

This crosssectional study is directed towards eighth grade students in their first year of high school. During this year, students begin regular science instruction and it is likely to be the most important year in the formation of attitudes relating to science. Four State schools and one Independent boys school in the Perth metropolitan area were involved in the study. These schools catered for a wide range of student backgrounds, and provided considerable variation in science instruction, ranging from teacher-centred methods to individualised, self-paced methods. The sample comprised ten intact and unstreamed classes taught for four hours each week by a total of seven teachers. Three schools (including the Independent school) provided two classes, the fourth school provided three classes and the fifth provided one class. A total of 313 students completed a questionnaire about their attitudes to science and science teaching. The questionnaire was administered in the middle of third term.

Instrumentation

Getting along with the teacher

This variable (GETALONG) was measured simply by asking students to choose which of three statements best described how they got along with their science teacher. The three statements were "we get along well", "we get along alright", and "we don't get along". It may be argued that such a broad operationalisation of the term is vague and open to many interpretations. Certainly a series of more specific questions, such as asking the student how often he argues with his teacher, would provide more variation in response, but these specific questions, too, are open to interpretation. For example, to some students an argument with the teacher may mean little more than silent disagreement, to others it may mean a lengthy verbal exchange. Some students may even enjoy arguing and regard it as a positive aspect

of their relationship with the teacher. Most people have an intuitive understanding of what it means to "get along" with someone, (a meaning which they may never need to formalise,) and it is each individual student's perception of this which is required. Further, partly because this perception is intuitive, it was felt that the student's response to this question would be representative of his relationship with the teacher over a long period, and it is this long period over which attitudes to science will be developed.

To determine whether students are able to distinguish between their perceptions of the teacher and their inherent interest in science, students were asked a question about the science teaching in their class. Here they indicated whether or not they liked science, and whether or not the teacher made it interesting. The actual wording of these responses is given in Table 1.

Science achievement

Achievement in science was the only cognitive variable measured in the study. A standardised test was not used to measure achievement for three reasons. First, while year eight science courses are based on a single syllabus, content sequence, emphasis and instructional methods vary from school to school. This makes difficult the development of a single test, fair to all schools. Second, practical constraints (length of testing time and the desire to minimise inconvenience to schools) would have necessitated a short test sampling only a small portion of content. Third, student achievement is not normally measured by a standard test, but a combination of test scores, assignments, reports and other classroom work. This study made use of a variety of assessment methods by asking teachers to provide for each student an achievement score based on all his science work during the whole of second term. To enable comparison between classes, each student was identified as being in the top, second, third or bottom quarter of his class. This four point scale is thought to provide a reasonably stable measure of the student's science achievement

Attitudes to science¹

Attitudes to science were operationalised using a conceptual model based on Bloom's (1976) discussion of subject-related-affect, his term for a student's attitudes to a school subject. Science-related-affect concerns the student's liking, enthusiasm and preference for science at school, and is conceived to be a resolution between the student's perceptions of his past history in related science learning tasks, his perceptions of the present learning task in terms of his likely success, and its relationship with the student's future goals or purposes.

¹ Affective outcomes usually associated with science classrooms are student attitudes to science (such as like-dislike) and scientific attitudes (such as openmindedness). Because the latter have a cognitive basis, only the former are considered here.

In keeping with this conceptual model, students' attitudes to science were measured with four separate scales. The INTEREST scale comprised twenty items designed to measure the student's interest, enjoyment, emotions and feelings on his science work at school. The student's perceptions of his past history in science was measured by ten items on the PAST scale. These sampled student's perceptions of his performance in terms of the reactions of himself, his teacher, parents and peers to the science work he had done. Perceptions of future success in science were gauged by asking students their expectations of performance in their next topic assessment, and in future science tests. Ten such items composed the FUTURE scale. Finally, the ten items of the USEFUL scale referred to the student's perceptions of the usefulness to him of the science topic in which he was presently engaged, and the more general usefulness of school science to his future goals.

The fifty items of these scales were distributed randomly in a single questionnaire. The items were of the typical Likert-style format and students were asked to respond on a four point scale - there was no neutral category. Approximately half of the items were worded in the negative direction. These scales were developed as part of an as yet incomplected larger study. Details of methods used to establish internal consistency and validity will not be discussed here, but Cronbach reliability coefficients of the ten item PAST, FUTURE and USEFUL scales are .84, .86 and .84 respectively. For ease of comparison, the reliability for the twenty item INTEREST scale was converted by a formula (Magnussen, 1967, p.73) to represent a ten item test and calculated to be .87.

Academic self concept

Three aspects of the student's self-concept of his ability in science were measured. The first of these sought the student's perception of his achievement in science compared to others in his class. This aspect was measured by asking students "how good are you at science, compared with others in your class?" Students responded by indicating the top, second, third or bottom quarter of the class.

The second and third aspects of academic self concept required the student to rate himself according to his success as a science student, and his work attitudes to science. A semantic differential technique, using ME AS A SCIENCE STUDENT as the concept and 4 bipolar adjective pairs for each aspect was employed. There were seven categories of response between each pair of adjectives. The four adjective pairs for the success in science scale (SUCCESS) were good-bad, worthwhile-worthless, successful-unsuccessful, knowing-unknowing. The work attitudes to science scale (WORKATT) used four different word pairs - quiet-noisy, careful-careless, busy-lazy, neat-untidy. The items were distributed randomly and half were worded in the negative direction. Cronbach reliabilities for the four item SUCCESS and WORKATT scales were .88 and .76 respectively.

Analysis of results

Methods of analysis

Nonparametric statistics were used to investigate the relationships between the three ordinal variables of getting along with the teacher (GETALONG), achievement (ACHT), and perceived achievement (PERCACHT) and the nominal variable of science teaching (SCITCHG). The statistical significance of the relationships was tested using χ^2 and the extent of association between ordinal variables is given by gamma (γ).

The variables measuring attitudes to science (INTEREST, PAST, FUTURE and USEFUL) and academic self concept (SUCCESS and WORKATT) were assumed to be interval and their interrelationships were examined using product-moment correlations, while their relationships with GETALONG were examined using analysis of variance. The appropriate statistic for the extent of association between an ordinal and interval variable is eta. Eta-squared (η^2) has an intuitive interpretation as the proportion of variance in the continuous variable accounted for by the ordinal variable. The difference between η^2 and R^2 gives an indication of the degree of linearity in the relationship.

All analyses were carried out using programs from SPSS - Statistical Package for the Social Sciences (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975).

Perceptions of getting along with the science teacher

Before exploring the relationships of GETALONG with the other variables, its dependence on the classroom teacher was inspected. For each teacher, some students perceived their teacher-student relationship as "get along well", some as "get along alright", and some responded "don't get along", indicating that, as expected, the teacher-student relationship is perceived differently by different students. A cross-tabulation of the GETALONG responses by teacher showed that these variables were not significantly related ($\chi^2 = 19.817$, $p > .05$), so it was considered unnecessary to distinguish between teachers in subsequent analyses.

The crosstabulation of GETALONG and SCITCHG is presented in Table 1, and the two variables have a statistically significant association ($\chi^2 = 134.87$, $p < .001$). Clearly, some students like science, some do not, and they may or may not find that the teacher makes science interesting. The marginal totals show that about 87% of students feel they do get along with the teacher, and about 82% felt the teacher's presentation of science was interesting, or at least OK. Although the largest groups of students are found in the middle categories of both variables, it is those students who like or dislike science (as opposed to responding science is OK) who best demonstrate the relationship between these two variables. If the like-science group (categories 4 and 5) and don't-like-science group (categories 1 and 2) are extracted from the 3 x 5 table, their 2 x 3 crosstabulations with GETALONG both

TABLE 1
Students Perceptions of Science Teaching by
Getting Along with their Science Teacher

	Perceptions of Science Teaching ^a					Row Totals
	1	2	3	4	5	
Group						
Get Along Well	0	4	43	12	64	39
Get Along Alright	7	19	69	23	31	149
Don't Get Along	17	8	3	9	2	123
Column Totals	24	31	115	44	97	311

Note: Two students omitted the item on science teaching

^a Responses to this item were

5. I like science and the teacher makes it interesting.
4. I like science but the teacher makes it boring.
3. Science is OK and the teacher is OK.
2. I don't like science even though the teacher tries to make it interesting.
1. I don't like science and the teacher doesn't make it interesting.

show a statistically significant association ($\chi^2 = 24.80$, $p < .001$ and $\chi^2 = 12.08$, $p < .01$, respectively) and a substantial relationship with $\gamma = .68$ for the like-science group, and $\gamma = .76$ for the don't-like-science group (γ is appropriate here because SCITCHG has become a dichotomous variable). In both groups there is a strong tendency for students who perceive themselves as getting along with their science teacher to perceive the lessons as more interesting than those who do not. This finding is not surprising, but importantly, the results overall make explicit that students do differentiate between liking science, perceiving how it is taught, and how well they get along with their science teacher.

Getting along with the teacher and achievement

The student's actual class position measured by ACHT is related to PERCAHT, the student's perceived class position ($\chi^2 = 165.86$, $p < .01$, $\gamma = .75$), with nearly half of the students accurately nominating their quarter of the class. Interestingly, more than two thirds of students perceived themselves in the top half of the class. GETALONG has a statistically significant association with both ACHT ($\chi^2 = 25.54$, $p < .001$) and PERCAHT ($\chi^2 = 39.95$, $p < .001$). Table 2 shows the crosstabulat-

TABLE 2
Students' Actual and Perceived Class Position by
Getting Along with their Science Teacher

	Position in Class				Row Totals
	Bottom Quarter	Third Quarter	Second Quarter	Top Quarter	
Actual Class Position (ACHT)					
Group					
Get Along Well	25	24	28	46	123
Get Along Alright	37	38	41	34	150
Dont Get Along	17	15	6	2	40
Column Totals	79	77	75	82	313

Perceived Class Position (PERCACHT) ^a					
Group					
Get Along Well	4	13	59	46	122
Get Along Alright	10	35	69	35	149
Dont Get Along	9	14	15	2	40
Column Totals	23	62	143	83	311

^a Two students omitted this item.

ion of both these variables with GETALONG. While GETALONG is related to both ACHT and PERCACHT ($\gamma = .31$ and $\gamma = .45$, respectively) it is related more strongly to perceived achievement. This is easily explained by assuming that the relationship between achievement and many student variables would be mediated by perceived achievement. The relationship between ACHT and GETALONG, controlling for PERCACHT is given by partial $\gamma = .10$, considerably less than the zero-order $\gamma = .31$.

Achievement, attitudes to science and academic self-concept

It was anticipated that the cognitive and affective outcome variables would be related. The association between the cognitive

TABLE 3

Standardised Group Means, and Summary Statistics for the
Affective Variables Analysed by Students' Actual and
Perceived Class Positions

	<i>n</i>	INTEREST	PAST	FUTURE	USEFUL	SUCCESS	WORKATT
Actual Class Position (ACHT)							
Quarter of class							
top	(79)	.45	.81	.58	.36	.64	.44
second	(77)	.20	.14	.14	.15	.16	.09
third	(75)	-.23	-.18	-.11	-.19	-.28	-.19
bottom	(82)	-.43	-.81	-.63	-.33	-.56	-.28
Statistics							
<i>F</i>		14.50*	55.67*	25.44*	8.25*	28.09*	10.29*
η^2		.12	.35	.20	.07	.21	.09
R^2		.12	.34	.19	.07	.21	.09
Perceived Class Position (PERCAHT)							
Quarter of class							
top	(84)	.49	.80	.61	.28	.68	.38
second	(143)	.12	.14	.17	.06	.13	.11
third	(63)	-.53	-.81	-.69	-.27	-.68	-.28
bottom	(23)	-1.08	-1.51	-1.38	-.63	-1.54	-1.31
Statistics							
<i>F</i>		27.92*	96.32*	54.68*	7.24*	67.01*	24.28*
η^2		.21	.48	.35	.07	.40	.19 ^a
R^2		.21	.48	.34	.06	.39	.17

^a Comparison with R^2 indicates a statistical significant deviation from linearity, $F = 4.65$ $p < .05$.

* $p < .001$

variable ACHT, and PERCACHT, the ordinal measure for academic self-concept has already been established. The relationships between these achievement variables and the six continuous affective variables INTEREST, PAST, FUTURE, USEFUL (measuring attitudes to science), SUCCESS and WORKATT (measuring academic self-concept), were determined using a series of one way analyses of variance. The results of these, together with values of R^2 and η^2 for each analysis, are presented in Table 3. Because the number and scoring of items varied among the affective scales, comparison between groups has been made easier by reporting standardised, rather than raw, mean scores in Table 3. Each affective variable has a substantial positive relationship with both actual and perceived class position, and the similarity of the values of R^2 and η^2 indicate that in all but one case this relationship was linear. For WORKATT, the comparatively low mean score of students perceiving themselves to be in the bottom of their class is responsible for the deviation from linearity. Not surprisingly, the PAST, SUCCESS and FUTURE scales held the most variance in common with these achievement variables, ranging from 48% to 20%. With the exception of the USEFUL scale, PERCACHT had a stronger relationship with each attitude than actual ACHT, a finding which supports the interpretation offered for its higher relationship with GETALONG. Each achievement variable accounts for about 7% of the variance in USEFUL. This finding suggests that the usefulness of science may have different interpretations for different students - for example, students may consider science to have a general usefulness whether they are high performers or not, and even if they are, they may perceive science as not particularly useful to their future plans.

Getting along with the teacher, attitudes and academic self-concept

The relationships between GETALONG and the six affective variables (INTEREST, PAST, FUTURE, USEFUL, SUCCESS and WORKATT) were first examined using analyses of variance. These results are presented in Table 4, together with values of R^2 and η^2 for each analysis. Again, standardised mean scores for each group, rather than raw mean scores, are reported in Table 4, to make easier the comparison of effect sizes. On every variable the difference between the mean scores of the extreme groups ("get along well" and "don't get along") are at least one standard deviation apart (the negative scores in the middle categories is a reflection of the frequency of response in each category), and each relationship is positive and statistically significant. For INTEREST and the two academic self-concept variables, SUCCESS and WORKATT, more than 20% of the variance in scores can be attributed to the relationship with GETALONG. Students' perceptions of their past performance in science, PAST, and the usefulness to them of science, USEFUL, have 15% of variance in common with GETALONG, while for FUTURE, the students' perceptions of his likely future success in science, the figure is 11%. The small differences between the values for R^2 and η^2 indicate that, in most cases, the relationship between the affective variables and the categories of GETALONG can be viewed as linear. Again, it is the relationship with WORKATT which shows a departure from linearity with a statistically significant difference between R^2 and η^2 ($F = 5.43$, $p < .05$).

TABLE 4

Standardised Group Means and Summary Statistics for the
Affective Variables Analysed by Getting Along with the
Science Teacher

	<i>n</i>	INTEREST	PAST	FUTURE	USEFUL	SUCCESS	WORKATT
Group							
Get Along Well	123	.49	.45	.37	.40	.45	.45
Get Along Alright	150	- .14	- .19	- .14	- .12	- .11	- .08
Dont Get Along	40	-1.01	- .65	- .64	- .82	-1.01	-1.10
<i>F</i>		47.10*	27.79*	20.15*	28.90*	42.13*	48.18*
η^2		.23	.15	.11	.16	.22	.24 ^a
R^2		.23	.15	.11	.16	.21	.22

^a Comparison with R^2 indicates a statistically significant deviation from linearity, $F = 4.65$, $p < .05$.

* $p < .001$.

TABLE 5

Correlation Coefficients and Communalities
for the Affective Variables

	1	2	3	4	5	h^2
1. INTEREST						.65
2. PAST	.61					.65
3. FUTURE	.64	.77				.68
4. USEFUL	.63	.41	.47			.35
5. SUCCESS	.61	.68	.67	.43		.69
6. WORKATT	.54	.48	.46	.36	.66	.42

Note: For all correlations, $p < .001$.

This series of results suggests that the affective variables are likely to be intercorrelated, and this was anticipated by the way these variables were operationalised. The interrelationship is confirmed by inspection of the matrix of correlations between the six variables presented in Table 5, together with the communalities or common factor variances for each variable. The INTEREST, PAST, FUTURE and SUCCESS variables are the most closely related. As might be expected, WORKATT correlates most highly with SUCCESS, while the variable with the lowest communality, USEFUL, has its highest correlation with INTEREST.²

Summary and conclusions

This study has established that the student's perceptions of how well he gets along with his science teacher are positively related to his achievement, his attitudes to science and his academic self-concept, specific to science. Students' science achievement (ACHT) was measured by his second term science mark. Students' attitudes to science were measured on four scales, the student's interest and enjoyment in science (INTEREST), his perceptions of his past performance (PAST) and likely future performance in science (FUTURE), and his perceptions of the usefulness of school science to him (USEFUL). Three aspects of academic self-concept were measured, the student's perceptions of his achievement compared to other members of his class (PERCACHT), his rating of himself as a successful science student (SUCCESS) and his work attitudes to science (WORKATT).

GETALONG is related positively and significantly to each of these eight variables, but the strength of the relationship varies. Although related to both ACHT and PERCACHT, GETALONG has a stronger relationship with PERCACHT. Of the affective variables, GETALONG is most strongly related to INTEREST and WORKATT with about 23% of variance in common. PAST and USEFUL have about 15% of variance common with GETALONG. It would seem that changes in GETALONG are associated with changes in the students' attitudes and performance in science, particularly their attitudes to science work. PAST and PERCACHT, both measuring perceptions of achievement in science, have nearly half their variance in common, and both are strongly associated with FUTURE and SUCCESS. PERCACHT has substantial relationships with INTEREST and WORKATT (about 20% of common variance), but much less with USEFUL (about 7%). The pattern of relationships of ACHT with all variables was similar to that of PERCACHT, but ACHT accounted for less variance, sometimes only half as much as PERCACHT. It seems that students' perceptions of achievement are a much stronger determinant of his attitudes, self-concept and

² Such a high degree of interrelationship suggests there may be some redundancy in the affective measures, that is, while conceptually distinct, these variables are not all empirically distinguishable. The possibility of redundancy was investigated using multivariate techniques which are not reported here. It was found, when PAST is included in the multivariate analysis with GETALONG, FUTURE is redundant, and when both PAST and WORKATT are included, SUCCESS is redundant. Thus the relationships of the affective variables with GETALONG can be adequately described by INTEREST, PAST, USEFUL and WORKATT.

his perceptions of how well he gets along with his science teacher. Thus it is not his actual performance which is important, but his performance as he perceives it in comparison with the performance of others in his class, and presumably, his perceptions of how they rate his performance.

There is no doubt that the relationships between all these variables are complex. Although the analysis has proceeded in most cases as though GETALONG (and at times PERCACHT) was an independent variable and the student outcomes were dependent variables, it is much more probable that the relationships are reciprocal and influence one another. For example, if an interested student works hard and experiences success, he perceives himself as successful and capable, and may apply himself even more, with a corresponding increase in achievement and positive attitudes. Extending this example to the present findings, the results suggest that such students are likely to perceive their relationship with their science teacher in positive terms. The student who perceives his relationship with his teacher in negative terms, by reporting that they "don't get along", does not necessarily have negative attitudes to science and to himself as a learner, but it is likely.

The importance of a positive self-concept for a student's future mental health has been discussed by Bloom (1976), who points out that students with low academic self-concept need to develop a positive sense of adequacy in nonacademic areas. However, research evidence suggests that a low academic self-concept increases the probability that a student will have a low general self-concept. Bloom suggests that up to 20% of students may experience symptoms of distress and alienation from school and adults, because of poor academic and nonacademic self-concept. From this reasoning it seems that the student most likely to suffer in this way is the one who has a negative academic self-concept, and who also does not get along with his teacher, as poor personal relationships make it difficult to develop a positive general self-concept. If teachers do influence students' self-perceptions (and research such as that by Nash, 1973, suggests they do), and, as this study shows, teacher-student relationships also influence students' self-perceptions, the teacher has the opportunity to work with students in an attempt to strengthen their self-concept. But how may this be done? There is no clear-cut answer. As Good (1979, p.63) points out, "research has little to say about how teachers might attempt to improve student growth in noncognitive areas". Even so, Good et al (1975) have provided some thoughtful comments in a discussion of their hypotheses about affective development. Further insight was provided by Nash (1974), who found that the teacher the student gets on with keeps order, keeps him busy, explains things to him, is interesting, fair and friendly. Perhaps as a starting point, a teacher could check his relationship with each student with each of Nash's six constructs, with a view to pin-pointing areas in which to concentrate efforts towards improving relationships.

So, does it matter whether students get along with their science teacher? From the results of this study, it appears that students' perceptions of getting along with their teacher have only a limited association with achievement, the strongest relationships are

with the affective outcomes of science. In contrast to those students who claim to get along well with their science teacher, those students who profess not to get along with their teacher tend to be, and perceive themselves to be, lower achievers, and less likely to achieve in the future, have less interest and enjoyment in science, see science as less useful to them, and have a negative concept of themselves as science students. Fortunately, these students are a minority, but this study suggests that they occur in most classrooms. If the teacher feels it is important that these students become more positive in their approach to science and their perceptions of their science ability, it is possible that the teacher can help by making a special effort to improve their teacher-student relationship with these particular students. How this can be done effectively is a problem not easily solved. Intuitively, it seems there may be as many solutions as there are students who feel they don't get along with their science teacher. But how many of these students would not want a solution to be found?

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USING THE LIBRARY AS A RESOURCE FOR SCIENCE TEACHING

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In school science programmes, teachers on the whole do not use the library extensively as a learning resource. The purpose of this paper is to consider the use of the library as a learning resource in science teaching and to present an approach which can provide library experiences within the school science programme.

SCIENCE AND THE LIBRARY

It is often acknowledged that an understanding of science is a basic necessity required for living in today's world. Furthermore, one of the responsibilities of school science programmes is to prepare future citizens to be able to make informed judgements on scientific and technology matters Jevons (1977). Concurrent with such a responsibility is the need for the school science curriculum to have as its major goal the development of

"scientifically literate citizens with the necessary intellectual resources, values, attitudes and inquiry skills to promote the development of many as a rational human being"

(NSTA, 1971, p.46)

The acceptance of this challenge at the lower secondary school level by science educators in Australia during the 70's is evidenced by the introduction of a broad range of inquiry oriented science curricula. In addition, innovative teaching practices have been utilised that promote such aspects of student development as, self directed learning, inquiry and problem solving skills. In this area the school science laboratory has featured prominently as a learning resource.

However, in many cases school science programmes remain to limit science instruction to the narrow confines of a single textbook and laboratory exercise in which the student repeats classic science experiments yielding well proven results. Within such narrow limits it is difficult for science to be presented as both dynamic and open-ended with the provision for a balanced consideration of scientific knowledge and processes. For scientific literacy to be a meaningful component of a science programme then planning for effective science teaching in this context would require extensive use of the library as a learning resource.

Many reasons can be advanced why science teachers do not extensively use the library as a learning resource. Perhaps a major reason is that the library is not seen as an integral part of the science curriculum by science teachers. Indeed the library is often seen as a place that should serve for the development of reading and library skills that have little, if any connection with the real world of science. However, the library is a major resource of any scientific research and should be regarded as a natural environment for scientific investigation in the same way as the laboratory. Furthermore, many students often have an inherent interest in scientific

topics that are available to them in a library. It is through the use of the school library that a student can obtain a broad background knowledge, a general enrichment, and an appreciation and understanding of the place of science in the world. Using a library resource centre effectively a student can gain a sense of proportion about science and can correct some common fallacies about science and scientists.

LIBRARY SKILLS AND SCIENCE TEACHING

If it is accepted that the library, like the school laboratory, is a learning centre for science then it is also apparent that the skills which can be acquired in the library are not necessarily peculiar to the library. The library itself can be seen as the vehicle for developing these skills. However, the value of a library as an integral component of a school science programme will depend to a great extent upon the students' own ability to make use of its resources. Thus central to the use of a library as a learning resource is the acquisition of those skills which will enable a student to be an independent learner. The skills and knowledge necessary for effective use of the library are listed in Table 1.

TABLE 1

DEVELOPMENT OF LIBRARY SKILLS THROUGH A SCHOOL SCIENCE PROGRAMME

KNOWLEDGE	SKILLS
Know how the library is organised and operates	Use of catalogue and indexes
Know various purposes and parts of a book and their special function	How to present conclusions
Know different types of information resources e.g. microfiche, book material etc.	How to obtain accurate information, facts etc.
Know the range of science information e.g. standard references, reports, theoretical information, magazine, journals, novels/factual and scientific.	How to sift through information and to find what is needed
	How to locate scientific information
	How to collate information from different sources
	Develop skimming and detailed reading skills
	Recreational reading skills
	Discriminate between different types of material
	Making an orderly search
	Using a bibliography
	Choosing an appropriate report method for presentation of final report.

There is a great deal of literature available on "library skills" and the various means by which these could be acquired by the student. However, the majority of references related to "library skills" (Coles & White, 1980, Powell, 1974) are usually concerned more with library orientation skills, as is the location and identification of resources. However, there is little guidance from the literature as to how students may acquire strategies and skills that would enable them to explore a given topic either independently or collaboratively with assistance from the teacher or teacher-librarian.

A METHODOLOGY FOR INCORPORATING USE OF THE LIBRARY IN A SCIENCE TOPIC

The library, like the school laboratory, needs to be seen as a learning centre for students in a curriculum context. Thus as a learning centre the library can be used by students to:

meet their needs for gathering information before or after a topic has been presented

meet their needs as individuals, so that they can pursue their own specific interests

develop their habits of using a variety of resources

work on projects either independently or in groups

become more proficient with reading or related learning difficulties.

This suggests that, if the library is to serve as a learning resource, then students need to develop skills that will enable them to work independently in the library. To make this possible one of the authors (Reid, 1980) has developed an audiovisual package that demonstrates how library and research skills can be developed using science as a vehicle to acquire such skills. The package contains a tape/slide set which shows students undertaking the various stages in a "library search" for a science topic. Some strategies for teachers, together with some topics which lend themselves to resource based learning, are included. An additional section in this package is a student guide with exercises designed to enhance a students' ability to use of library resource centres.

Some of the aspects which can be developed through use of the library resource centre and which can be initiated by the resource package are shown in Table 2. Whilst not claiming to be comprehensive, the list of skills is one which hopefully will be used by the student as a "life long" rather than a "short term" method. The strategy for student development of library and research skills via the medium of a science topic is presented in Figure 1.

An example of a question that could be researched by students is as follows:

"Explain how man, as a part of the ecosystem, is endangering whales to the point of extinction".

As an initial language experience the teacher could motivate the students on this topic by use of a variety of resources on whales e.g. a cassette tape "The Song of the Hump Back Whale; extracts from Moby Dick; pictures of Scrimshaw's work, a record of sea shanties used by Nantucket whalers; a video tape of the last whale hunt at Albany; and some selected poetry on whales. Then the students would be asked to analyse the question and identify some key words. Some of these would be "ecosystem, endangering, whales, extinction". Using these key words as a base the students and teacher build up an explosion chart (concept map) of linked ideas. This

enables the students to gain as many points of entry as possible into the resources that are available in the library. The class is then divided into suitable small work groups of say, four students and each group is assigned a subset of the main explosion chart of the topic.

In outlining the topic, the teacher sets some reasonable limits on the research areas and also defines some of the expected outcomes. For the topic on whales these might take the form:

1. define endangered species
2. compare extinction through natural evolutionary processes with extinction through man's intervention
3. describe some of the actions individuals might take to intervene when a species is placed on the danger list.

Suitable open ended questions need to be organised by the teacher and students using as a basis, the key words. The students then undertake the search of available resources and process the information they have gathered into a format which is suitable for communication to other students. During the search process it is necessary to remind the students to record references to entries which appear to be "dead ends" as well as those which are more appropriate to the main question.

Assimilation of the information gathered in the student's search is fostered by group discussion with the teacher acting as a resource person. Finally the students in consultation with the teacher decide on the mode of presentation e.g. tape cassette, posters, written report or a class report.

TABLE 2

ASPECTS THAT CAN BE DEVELOPED THROUGH LIBRARY RESOURCE CENTRES

KNOWLEDGE SKILLS TO BE DEVELOPED

Data collection

Analysis of data

Problem solving skills

Creative thinking

Understanding of science and scientific method

Skills in written and oral communication

Formulation of hypotheses or questions to be investigated

Generating and formulation of new questions or hypotheses based on findings of library research

Discrimination between essential information and interesting peripheral information

ATTITUDES TO BE FOSTERED

Working cooperatively in groups to produce a product

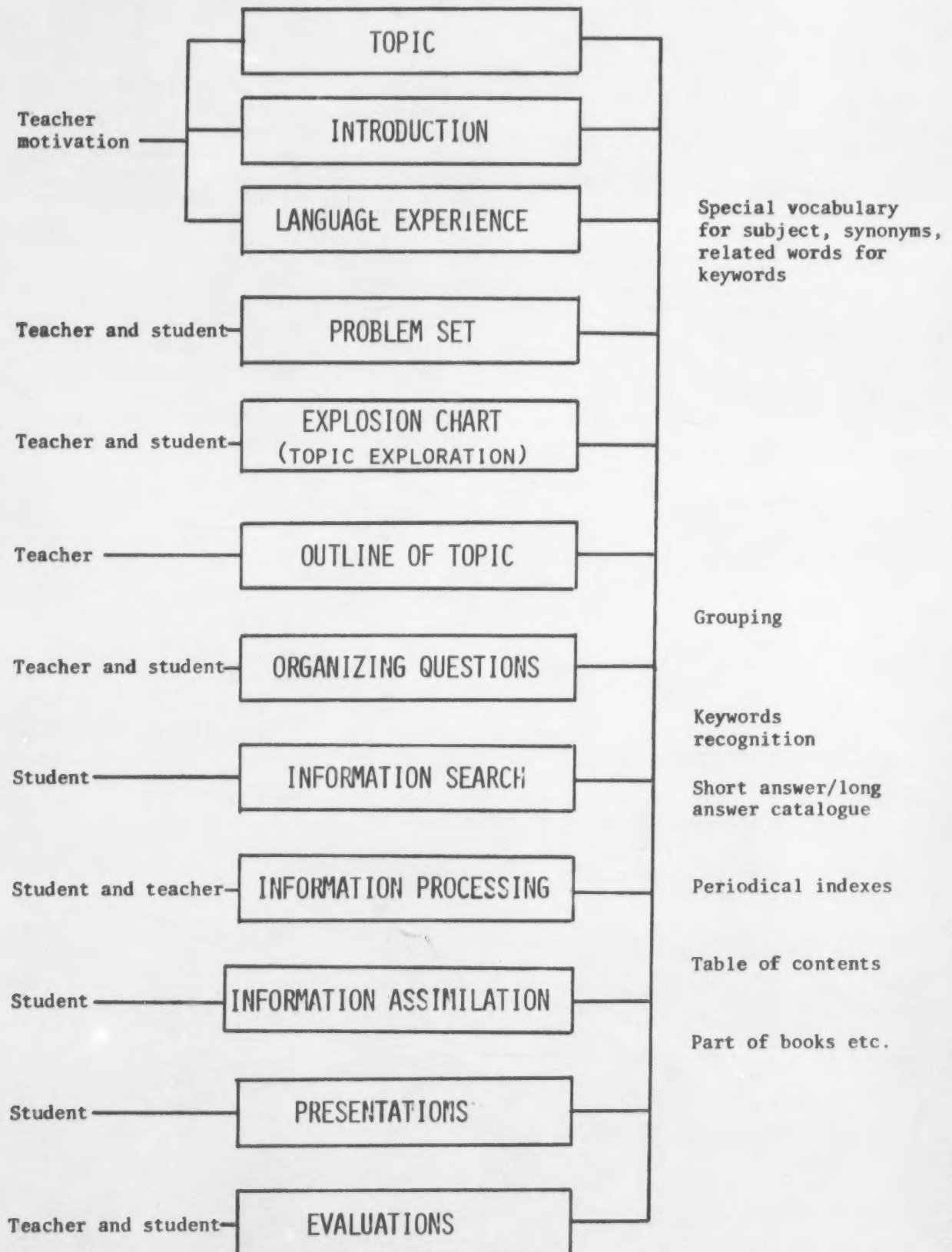
Ability to study independently

An appreciation that the study disciplines are interrelated

Positive perceptions of one's ability to understand and offset one's environment

Figure 1

FLOW CHART FOR RESOURCE BASED SCIENCE LEARNING



Prior to the presentation of the final report both students and teacher agree on the manner in which the piece of work is to be assessed. Student participation in the decision making process of evaluation is an essential component in developing the ability to be an independent and self motivated learner.

The strategy outlined here is viewed as being suitable for students from upper primary years to year 10 in the secondary school, catering for all abilities within this age range. It is intended as an adjunct to other learning experiences in science, not a substitute for current practices. Using the library in this way fosters independent as well as group learning situations and provides the student with an opportunity to examine and research information which is often given low priority in reading and library skill development.

As with the use of any instructional strategy the ultimate success of this particular methodology is dependent upon the teacher. In this instance the development of library and research skills will require the science teacher to determine the availability of the topic resources appropriate at the student level in collaboration with the teacher-librarian. and cooperate closely with the school librarian to ensure that the required library resources are actually available to students when required. Furthermore in all facets of this methodology the teacher, teacher-librarian and the students need to work cooperatively to achieve a successful outcome.

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SELF EVALUATION OF TEACHING EFFECTIVENESS

IN SCIENCE : A MODEL

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Introduction

A theoretical base for improving aspects of teaching can be built from the development of value traits (Kratwohl et al, 1964), the role of discordance in change and in learning (Festinger, 1959; Johnson and Johnson, 1979) and methods for the generation of ideas and resolution of conflicts (such as Delphi and nominal group methods developed respectively by Dalkey and Helmer in about 1952 and Delbecq and Van de Ven in 1968). The model proposed in this paper uses nominal group methods, focussed on student feedback, to identify discordance of opinion about teaching effectiveness in order to question value traits about teaching effectiveness held by science teachers. The model uses current value traits of science teachers as its starting point. It is developmental in nature and actively supports the principle of self evaluation as a basis for professional development.

Four Major Ideas Implicit in the Model

There are four major ideas implicit in the proposed model. The ideas are:

1. that student feedback is seen by secondary science teachers as having a useful role to play in the evaluation of teaching effectiveness.
2. that discordant opinion about teaching effectiveness is worth identifying because it can cause teachers to actively search for an explanation for the discordance. Also, it can provide a focus for the development of teaching effectiveness.

3. that a professional development model should be developmental so that teachers decide priorities within their own set of values. A collaborate developmental group methodology such as that provided by a combined nominal group technique and Delphi technique is a powerful and protective process for the generation and evaluation of ideas about teaching effectiveness.
4. that an emphasis on teacher self evaluation is professionally more desirable than continued reliance on evaluation of teaching effectiveness by external evaluators. But self evaluation must in some way be moderated against peers to reduce the likelihood that an individual will ignore or rationalise away unsatisfactory feedback as "normal". The science staff of a large secondary school, or from a consortium of schools, would provide a representative peer group against which such moderation can occur.

Student Feedback

There is extensive literature on the role of student opinion feedback in the evaluation of teaching effectiveness. An overview is provided by Page (1974). A review of recent papers and the diversity of issues associated with student opinion feedback is presented by Betjeman (1980). A summative statement that reflects the literature on student feedback is provided by Johnson (1976)

.... whatever techniques we might use, it would seem more than a little short sighted to ignore a primary resource - the pupils.

(Johnson, 1976, p.36)

Discordance

The role of discordant opinion is an important feature of the model. Discordance can be defined as a disagreement or difference of opinion. According to Festinger (1959) it is discordant feedback that is most likely to open a teacher to change. Prior to explaining a theory of cognitive dissonance and citing the evidence for it, he makes the following introductory comments.

The individual strives towards consistency within himself. His opinions and attitudes ... tend to exist in clusters that are internally consistent. ... inconsistencies ... capture our interest primarily because

they stand out in sharp contrast against a background of consistency. There is the same kind of consistency between what a person knows or believes and what he does. ... in the presence of an inconsistency there is psychological discomfort. ... as soon as dissonance occurs there will be pressures to reduce it.

(Festinger, 1959, pp.1-2)

The construct of discordance has a fundamental role in the learning process. It is consistent with current understandings in educational psychology to use discordance as a basis for developing teacher understanding of teaching effectiveness. Johnson and Johnson (1979) reviewed 144 papers on the role of discordance in learning. They cited evidence to support the proposition that discordance generates cognitive disequilibrium which may eventually lead, through an active searching for alternative ideas, to higher quality understanding. If a teacher can be placed in an appropriate situation that generates discordance about teaching effectiveness then it may result in improved understanding about effectiveness and susceptibility to change. Such a situation should provide a diversity of ideas that might lead to personal internal discordance and that can be evaluated in a non competitive or non discordant atmosphere.

A source of discordance, directly related to a teacher's classroom, may arise by comparing the teacher's opinion about teaching effectiveness with the opinions of students and colleagues.

Collaborative Developmental Group Methodology

A clinical situation in which there is a one to one relationship between teacher and observer - evaluator is expensive with personnel time and does not give enough penetration of the total teaching staff. By its insular nature it may not lead to exposure to a wide range of alternative ideas. An unstructured round table meeting of teachers is also relatively unproductive in generating and resolving discordance. Cyphert and Gant (1971) claim that the final position arising from such a meeting is not true consensus due to influence of psychological factors. These include dominance of authority figures, dominance by the loudest voice, unwillingness to abandon an opinion once it has been publically expressed and a bandwagon effect of majority opinion. Other criticisms of such meetings are made by Van de Ven and Delbecq (1971). They add influences such as a focus effect (falling into a group rut), unwillingness to express covert judgements honestly or completely and the tendency for the group to reach speedy decisions before adequately exploring an idea. Unstructured meetings of teachers are less likely to test or change an individual's opinion.

There are a number of methods that could be used to confront a teacher with a wider range of ideas. Five are described by Lefrancois (1975) but there are two important methods missing from his list, namely Delphi and nominal group methods. These are more appropriate for generating ideas and resolving discordance. Johnson and Johnson (1979) also suggest that the latter process is enhanced by ensuring a heterogeneous composition of the group. The two methods are described and compared by Delbecq, Van de Ven and Gustafson (1975). Lonsdale (1975) suggests a way of modifying and combining both methods. These modifications are derived from the work on nominal group method by Delbecq and Van de Ven in 1968. Van de Ven and Delbecq (1971) claimed that a nominal group method is successful in overcoming or reducing many of the inhibitory influences operating in less structured group processes. In particular it reduces dominance and confrontation, stimulates creative tension and ideas generation, maximises individual participation and delays premature evaluation and rejection of ideas. In addition if time for meetings is limited, as it is in a normal school situation, nominal group technique can be made to operate on the one topic over a series of meetings.

Neither Delphi nor nominal group technique was designed for the specific purpose of aiding teacher development. Both are procedures for the creative generation of alternative ideas and the finding of creative group solutions to problems. They both deliberately avoid overt conflict. Their important contribution to the proposed model is that they expose individuals to alternative ideas and, in a non threatening way, they help prioritise ideas of the group. As elements of both Delphi and nominal group technique are useful a combination could provide a useful process for teacher development. If such a process could be linked with discordant feedback on teaching effectiveness it may be possible to generate alternative ideas, create personal discordance and enhance possible change in selected teaching behaviours. To concentrate on developing an awareness of teaching effectiveness and possible directions of change is important. Bryant and Haack (1977) concluded that success in any teacher development effort is dependent on

... identifying competencies to be improved, criteria used in evaluating competencies and the basis used for enabling discussion between teachers and/or resource personnel about the improvement of instruction.

(Bryant and Haack, 1977, p.609)

Self Evaluation

Over the recent decade the notion of self evaluation and self development has received increasing attention in educational literature. For example the National Science Teachers Association of the United States of America, in describing "conditions for good science teaching in secondary schools", emphasised a need for self evaluation and personal teacher initiative

... for as long as he continues to teach he must be given every opportunity to increase his knowledge and improve his skills ... and special incentives to encourage self improvement.

(NSTA, 1970, p.14)

O'Hanlon and Mortesen (1978) reviewed approaches to the evaluation of teaching and recommended that multiple evaluation procedures are required and that student and self evaluations should be included. Simpson (1966) states that self evaluation is an essential part of professional behaviour.

A fundamental shift in emphasis towards self evaluation may be desirable to create and maintain a focus on issues of professional development closely related to effectiveness in the classroom.

The Three Phases in Implementation

The implementation of the model consists of three phases.

1. Generation and evaluation of ideas about teaching effectiveness.

This phase necessitates at least three, but perhaps no more than four, meetings to clarify the area of effectiveness to be surveyed and to generate the criteria to be used. Meetings would be interspersed with contacts at an individual level. The process is a combination of nominal group and Delphi techniques.

Individuals are exposed to group ideas in order to improve the breadth and quality of their own ideas or to reinforce them. Participants would experience controversy if personal ideas did not match those of their peers. The protective nature of nominal group technique would facilitate participation and assist individuals in evaluating their ideas, and as a consequence, moving towards a better understanding of effective teaching.

The opinions of individuals are moderated by those of their peers and the quality of thinking by the group sets the standard.

2. Identification of discordant student and teacher opinion about teaching effectiveness.

This phase involves the trialling and use of a student and teacher survey instrument based on the criteria previously identified. A group leader or facilitator with appropriate skills in the development of survey instruments could be responsible for this phase and leave other participants to resume normal duties. A period of one month would probably be adequate to trial, analyse and revise. Personal teacher feedback documents could be easily produced using the set of computer programmes previously outlined.

3. Generation and evaluation of ideas about possible teacher responses to particular discordant feedback.

This necessitates meetings of colleagues to identify possible causes of, and hence responses to, specific discordant feedback. The process would mirror that used in Phase 1 and could make teachers aware of a wider range of possible responses. Awareness of a discordant opinion may not result in any response to that 'problem'. But by spelling out alternative lines of action the likelihood of some response is enhanced. This could further be enhanced if uninvolved resource personnel were available on request to assist potential respondents.

The proposed model is essentially self evaluation moderated by peers. As Brandenburg et al (1979) state when reviewing evaluation programmes for teaching effectiveness:

Self evaluation is the apex of (teacher) involvement in the evaluation process. Utilization is enhanced since the (teacher) is both the source and receiver in the communication process. If the self evaluation process is done with the help of a colleague or instructional 'expert' additional opportunities are provided to obtain critical review, useful suggestions and support.

(Brandenbrug et al, 1979, p.11)

In the proposed model the individual in the group is the source and the receiver and the other members of the group provide critical review, suggestions and support. So the individual gets feedback on criteria he helped establish. The model relies on the identification of discordant opinion between students and teachers about criteria of teaching effectiveness regarded as important by the group and on the magnitude of discordance generated by the group. This means that standards are determined by the group. Standards in the model are not absolute and could be expected to vary from group to group and within

a group over a period of time. With reasonable guidance by a group leader or facilitator the standards set by the group become self-improving. As the standards of the individuals in a group improve, the mean group standard also improves and continues to exert pressure on participants to further increase effectiveness to remain at least "average". Thus the focus for the development of teaching effectiveness does not depend on comparisons with 'good' or 'bad' models of teaching effectiveness.

The effectiveness of the proposed model in contributing to professional development depends on the resolution, in full or part, of discordance. If that occurs there is consequential increased likelihood that teachers will use this type of feedback again at some future time. If teachers could be convinced that exposure to discordance has the potential to decrease future related discordance then they may tolerate or even seek further discordant feedback. But if exposure does not lead to a decrease of that discordance, if the feedback and follow up are not seen to be useful, then teachers may actively avoid further discordant feedback. In the proposed model it is important to try to convince participants that by identifying discordant opinion it is then possible to try to reduce it. It is also important to actively encourage and assist teachers in analysing what the discordance might mean and in providing ideas and assistance with possible responses. The discordance that is generated is not related to only the personal feedback document. Discordance is generated in all three phases of the model. The resolution of discordance can occur in all three phases but the significant phase for resolution is the last.

The proposed model could be adapted even if it were considered difficult to provide a competent leader or facilitator with appropriate skills and time or considered desirable to increase teacher access to student feedback at an educational systems level. One adaptation could be to establish an item bank of acceptable criteria of science teaching effectiveness. Phase 1 would proceed as described but the purpose would be for a science staff group to debate the relative importance of items in the bank, rather than to generate their own criteria, and to select a subset to be used for the evaluation of their teaching effectiveness. To alter Phase 1 from an interactive group process to the selection of criteria from the bank by an individual isolated teacher might provide increased personal construct validity for the resultant questionnaire, but would bypass the group interaction which makes up an important component of the methodology. Phase 2 would be reduced to the administration of subsets of items previously validated prior to their entry into the item bank. Data would be processed to identify discordance of opinions as described in this paper. The data pool cumulatively stored and modified for the item bank could function as the data source for peer teacher moderation. This would allow the model to be used by small groups of science teachers and not rely on a consortium of science staffs to provide a large enough teacher sample for peer teacher moderation. Phase 3 would remain unchanged. Despite the possible modifications the four major ideas basic to the model would maintain their significance.

The four major ideas behind the proposed model have considerable support through evidence and opinion cited in the research literature and as reviewed by Betjeman (1980). Brandenburg et al (1979) described ten indicators for implementing an effective evaluation programme of instructional quality and the model has the potential to satisfy all of them. It gives feedback on consensus goals in a safe professional climate, it is directed to an effect, the instrument can have satisfactory technical quality, the criteria are representative, it is seen by users as useful, it fits the constraints of a school timetable, the feedback can eliminate numbers to make it more readable, it can be implemented impartially and with confidentiality and is feasible in terms of time and cost. The model is directed mainly towards self evaluation. As Levin (1979) concludes when reviewing research on teacher evaluation:

Self evaluation does result in
behaviour change ... but these changes
were not always at the level of
significance.

(Levin, 1979, p.243)

He claims that if self evaluation occurs then it does cause change. Perhaps such a level of confidence is not warranted but if the proposed model generates any degree of self evaluation it will be useful. Centra (1977) in summarising his thoughts about evaluating teaching, made the following statement. It also encapsulates the hopes held for this model. He writes:

Some (schools and teachers) have
already implemented worthwhile
innovations and improvements in
instruction. Others will probably
never change much, secure in their
belief that they are already doing a
good enough job. Still others,
however, are ready to take a closer
look at their teaching and are open to
new ideas.

(Centra, 1977, p.106)

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